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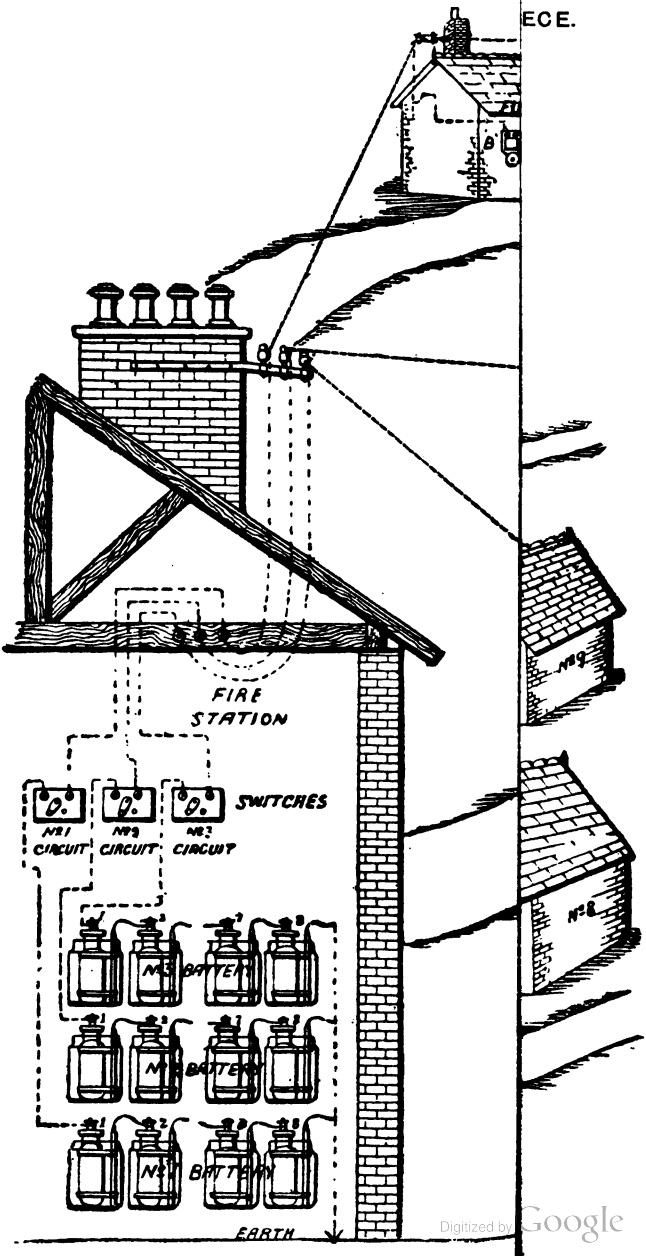

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PRACTICAL ELECTRIC BELL FITTING

A TREATISE

ON THE

FITTING-UP AND MAINTENANCE OF ELECTRIC BELLS AND ALL THE NECESSARY APPARATUS

BY

F. C. ALLSOP

WITH ONE HUNDRED AND EIGHTY ILLUSTRATIONS

TENTH EDITION

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PREFACE.

THE favourable reception accorded a series of articles by the author on electric-bell fitting which appeared in the 'English Mechanic' in 1887, induced him to issue them in book form. The fact that four editions have been rapidly exhausted is sufficient evidence that it has supplied a long-felt want, and in issuing this (the fifth) edition the author trusts that the revisions effected, and large amount of fresh matter that has been added, will considerably increase the value of the book.

To deal with the subject in an explicit and thoroughly practical manner has been the chief aim; while to avoid unnecessarily confusing those who glance through the book merely to get sufficient knowledge to enable them to do electric-bell work successfully, only such apparatus has been described as has after a thorough test been found reliable and is in use at the present time.

F. C. ALLSOP,

MANUFACTURING ELECTRICIAN.

23 BUCKLERSBURY, LONDON, E.C.

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PRACTICAL

ELECTRIC BELL FITTING.

CHAPTER I.

WIRES AND WIRING.

So great has been the improvement of late years in electric bells that the question of their reliability, a doubtful point a few years back, is now placed beyond controversy. Very few new buildings are now erected that are not fitted throughout with them, and builders have at last recognised that even for small houses electric bells are the cheapest, as well as the most reliable and convenient means of communication.

The main points to be looked to by those who desire to attain any degree of success in electric-bell work, are (1) *to obtain a sound knowledge of the principles underlying the working and arrangement of bells, indicators, &c.*, (2) *to use only good and reliable apparatus*, and (3) *to be thorough in all work.*

Next to ignorance, perhaps, the greatest evils result from the use of inferior wire, as bells and indicators are always accessible; while renewing faulty wires after a building has been completed and finished can only be done at great expense and trouble, and at an inconvenience to the householder that requires first to be experienced to be appreciated.

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Choice of Wire.

For inside work the wire almost universally now employed is No. 20 or 22 I.R., double cotton covered and paraffined. The wire (see Fig. 1), which is usually tinned, is first covered with a wrapping of india-rubber strip, followed by a number of longitudinal strands of cotton, round which are wound other strands of cotton, the whole being afterwards immersed in melted paraffin wax and polished by friction. Gutta-percha wires were formerly much employed, but have since given way to the I.R., owing to their unreliability in dry situations or situations alternately dry and damp, in which places the insulation after a little while cracks and is easily rubbed off with the finger. I.R. wires are also to be obtained with the outer covering of cotton, instead of being simply wound round the wire, plaited round it. Wire thus treated is known as "braided," and, though rather dearer in price, is to be preferred, as the ends, when stripped, have no tendency to unravel, a great fault of the ordinary paraffin wire. Owing to the variety of colours and patterns in which it can be obtained, paraffin wire is very suitable for running round skirting and places where it is exposed to view.

FIG. 1.—PARAFFINED ELECTRIC BELL WIRE.

When ordering wire it should be obtained in two or three different colours, the main battery wire from the carbon terminal being kept of one colour, and those from the pushes of other colours, according to some plan, so as to be able to distinguish them in the future. This rule should be strictly adhered to, as it not only greatly facilitates matters in first laying the wires, but should a fault subsequently occur, the faulty wire having been found at one place, there is no difficulty in

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identifying it at either the push or battery end. Many large bell fitters have some special rule as to colours, but the writer has always found white for the main battery wire, and blue, red or green for the other wires, all the distinctions it will be necessary to make.

Quite recently the wire manufacturers have introduced a new class of wire for bell work, consisting of a double lapping (laid on in alternate directions) of cotton saturated under pressure with their patent insulating compound, the whole afterwards being braided and immersed in paraffin wax. The wire has great lasting qualities, and has found much favour with electric bell fitters, while for a braided wire it works out considerably cheaper than the I.R., and is, the writer thinks, more durable.

Wherever possible, the fitter is strongly advised not to employ a wire of smaller gauge than No. 20, as smaller wires are ill fitted to withstand the rough usage to which they are so frequently treated when being drawn through tubes, or, if stapled round the skirting, to the accidental knocks and injury to which they must necessarily be subjected. There is no disguising the fact, however, that a very large proportion of electric bell installations are carried out with No. 22, and that competition compels its use in many instances; nevertheless, the extra risk incurred by its employment is really not worth running, considering the slight extra cost of the No. 20 over the No. 22.

Sometimes, with a view to economy, the "main" wire, i.e. the wire that runs from one pole of the battery to one of the springs of all the pushes, is heavily insulated, and the "line," or remainder of the wires, covered with a second-rate insulation. But this method is not advocated, it being the cheapest in the end to insulate all the wires equally well. For although no leakage takes place from pole to pole of the battery,

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owing to the main wire being well insulated and ending at the pushes, yet, after a time, leakage may take place between the line wires themselves, causing, perhaps, when a push is pressed, two or three shutters of the indicator to fall in addition to the right one.

Wires in Tubes.

In fixing the wires the method employed will, to a certain extent, vary to suit the particular requirements of each case. In a new building the wiring should be commenced as soon as the bare walls are up and the roof on. In this case the wires should be placed in light zinc tubes, and the tubes nailed to the walls with stout 2-inch floor-brads. As the walls would not at this stage be plastered, an uninterrupted run can be secured from the top to the bottom. Care must be taken, in sliding these tubes over the wire, not to abrade the insulation, and never put more wires in one tube than will slide through *easily*.

When wires are run in zinc tubes there are two methods that may be adopted: (1) the wire and tubes may be fixed at the same time, or (2) the tubes may first be nailed to the walls, and the wires drawn in afterwards. The first is without doubt the best and most expeditious method. The objection generally urged against it is that the plaster being put on after the tubes are fixed, the damp during the drying of the walls passes into the tubes and affects the insulation of the wires. No doubt during the drying of the walls some moisture does collect in the tubes, but it soon dries out, and if the size wire advocated here is used, the moisture is not in the tubes long enough to do any harm.

In the second method, however, it is never possible to get straight runs for the tubes, and unless the tubes are *very carefully* fixed, some abrasion of the wires is sure to take place when they are being drawn in, which sooner or later develops into a serious fault. In putting in wires by the first method,

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the wire is first cut off the right length, and the different lengths of tube slipped over and nailed up to the wall, one length of tube being fixed before the next length is put on. In the second method a bare copper wire is passed through the tubes from the top to the bottom while they are being fixed. When the plastering is dry, the insulated wires are pulled into the tubes by means of this copper wire, an assistant at the bottom fastening the end to a coil of insulated wire that he has by the side of him. He then gives a signal, and the wire is drawn through the tube, the assistant carefully guiding the wire into the tube, and preventing the wire getting into kinks.

In joining the lengths of tube, the end of the one should be slidden over the other for about an inch or so. To do this, open the end of the length of tube, which you are going to add, with the pliers, so that it will pass over the next, bend the edge of the inner one slightly outwards, and then slide the other length over it, as shown in Fig. 2; this will prevent any abrasion of the insulation should it be necessary to pull a new wire through at any future time. Try to get as straight a run for the tubes as possible, so as to facilitate renewing a wire should it be absolutely necessary.

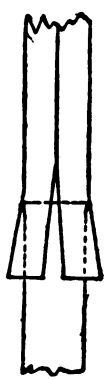

FIG. 2. JOINING TUBES.

The position of the pushes should be determined as early as possible, so that the blocks to which they are to be fixed can be put in their places. When the position has been determined, which is generally not until the plastering is done and the chimney-piece fixed, the plaster must be cut away to permit a round, bevelled wood block (shown in perspective in Fig. 3 and in section in Fig. 4) being nailed with two or three floor brads to the brickwork. This block, made prefer-

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ably in elm, is 3 inches at its greatest, and 2½ inches at its smallest diameter, and of such thickness that when it is fixed its face comes flush with the surface of the plaster. As will be seen from Fig. 3, there is a groove cut from one side to the centre, so as to allow the tube carrying the wires to enter a little way. In rooms where there are two pushes, one on each side of the fireplace, it is preferable to take the tubes carrying the wires round the hearthstone and under the floor instead of going round over the mantel-piece.

FIG. 3.—PUSH-BLOCK.

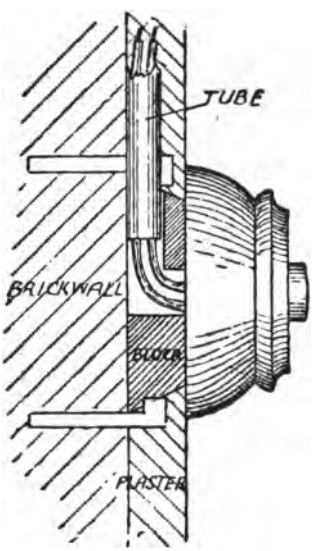

FIG. 4.—PUSH-BLOCK FIXED.

Wires on Surface.

If the building to be wired is in a finished state, tubes cannot, of course, be employed. In this case the wires should be run round the skirting board and under the floors, fixing the wire with small staples (see Figs. 5 and 5A). Do not, however, drive a staple so far as to injure the insulation, and *never* put *two wires* under *one staple*, or allow two staples to touch one another. All staples, especially those used for outdoor work or in exposed places, should be well galvanised or coppered. If the sight of the wires is objected to, a light ornamental casing to match the skirting may be employed to contain the wires in such places as they are exposed to

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view; this will also serve to protect the wires from mechanical injury.

Where wires are run under the floors in the same direction as the boards, they should be placed in small notches cut in the top of the joist, ½ inch apart, in the *centre* of the floor board. If the wires are placed near the edge, they are liable to be

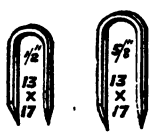

FIG. 5.—ORDINARY STAPLES.

FIG. 5A.—INSULATED STAPLE.

injured in screwing down the board. If there are many wires, the practice of notching the joist is not advocated, as it weakens the joist. A better plan is to bore a hole for each wire about 2 inches from the top of the joist, as this practically does not weaken them at all. When the boards are replaced, care should be taken to see that they are screwed and not nailed down, to allow of ready access.

Outdoor Work.

For outdoor or exposed places, No. 18, 20 or 22 wire, covered with a layer of gutta-percha, then wrapped with tape and well served with Stockholm tar, is generally employed, though some persons prefer to use the vulcanised rubber covered wire as used for electric light work. Whether covered with gutta-percha or india-rubber, these wires are known as 20/14, 20/12, or 18/10, the first number denoting the gauge of the wire, and the second the thickness to which the gutta-percha or india-rubber covering is carried. No. 20/14 is a very serviceable size, and sufficient for all ordinary purposes.

In fixing outdoor wires the best plan is to fasten them to the wall by large, stout staples, or, if this is objected to,

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pipe-hooks can be driven into the wall at intervals of 6 or 8 feet and the wires tied to them by tarred yarn. If staples are used, care must be taken not to drive the staples quite home, as this would pinch the wire and injure the insulation.

In places where communication has to be extended to an outbuilding some distance off (such as from the house to the stables), a naked wire is taken overhead. For this purpose No. 16 or 18 B.W.G. hard-drawn copper wire should be employed, the wire being fixed on insulators either supported out from the walls by an iron bracket, or slung by means of 7–18 galvanised iron wire from the most accessible chimney-stacks. Fig. 6 shows a small insulator much used where frequent supports are necessary and the route of the wire somewhat sheltered. The insulator is fixed by an ordinary wood screw, which is passed through the centre of the bobbin.

FIG. 6. PORCELAIN BOBBIN.

FIG. 7.—INSULATOR.

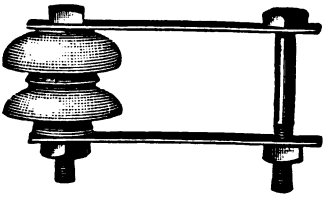

FIG. 8.—SHACKLES.

Fig. 7 shows a small insulator, for use where a better insulation is desired; and Fig. 8 the usual form of shackle employed for electric bell work. The G.P. leading-in wire should be joined to the line wire at the last insulator, and passed down the side of the building into the interior through a hole that has been previously knocked through. The leading-in wire, before passing into the hole, should make a dip below and

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then bend up again, so as to cause any water running down to drip off at the bend. In some cases the use of overhead wires is objected to on account of their unsightliness. The wire (such as is advised for outdoor purposes) may then be placed in ¾ iron piping, or in a small, creosoted wood casing, laid underground at about 10 inches or 12 inches from the surface. Such a casing is shown in Fig. 9. It can be constructed very cheaply, and is to be preferred to iron pipes in most instances, from its accessibility at all parts. In going under roads, however, and ground where there is much traffic on the surface, iron piping should invariably be used, care being taken to get the joints perfectly watertight.

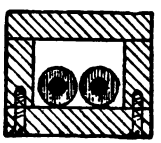

FIG. 9.
UNDERGROUND CASING.

Earth Connections.

Where an earth return is necessary, care should be taken to obtain a good connection. Some people seem to have an idea that any flimsy attachment, such as twisting a wire round the nearest gas bracket, is efficient. This, though it may be simple, is by no means efficient, and as the wire rapidly oxidises, a break in the communication occurs a day or two after the apparatus is fixed. To make a good earth connection, the following plan should be adopted :—Having selected the most accessible point in the nearest water main, and scraped the pipe clean for a length of about 3 inches, take a piece of naked copper wire, No. 16 B.W.G., about 2 feet long, previously brightened with emery paper, and twist this tightly round the pipe, leaving a tail of about 6 inches; then solder the whole well together. Now run your earth wire, which should consist of No. 16 naked copper or 3–16 galvanised iron wire, twisting and soldering this to the projecting tail.

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If this is properly done, an excellent and lasting earth connection will be secured. Great care should be taken to see that this is not a cistern-pipe, for, if so, there will be a "bad earth," caused by the break in continuity at ball-cock in the cistern.

Should there be no water main within reasonable distance, attach to the gas main, the street side of the meter (if on the house side the meter must be bridged over with a piece of wire), owing to the white and red lead used in the joints making a very bad electrical connection. Never, if it can possibly be avoided, have the earth connection on the water main at one end, and on the gas main at the other, as permanent currents are thereby often set up.

Should neither a water or gas main be obtainable, a pump pipe leading to a well makes a good "earth." Failing this, an artificial earth must be resorted to, which should be made thus:—Suspend about 5 feet of sheet-lead 6 inches wide in the centre of a hole about 4 feet deep, then ram in with ordinary gas coke till within 6 inches of surface, when fill in with soil. The earth wire must then be soldered to the projecting end of the lead. Care should be taken to obtain as moist a situation as possible for the hole.

Where wires are exposed to view, particular attention should be paid to the running of the wires, so as to give them a neat appearance, as nothing forms a greater eyesore than carelessly run or improperly stapled wires.

We give below a list of the principal tools, &c., required in electric bell-work, both for indoor and outdoor circuits.

FOR INDOOR WORK:

1 long "bell" gimlet.	1 pair of taper nose cutting pliers.	1 file, 8-inch, half-round.
2 small gimlets.	1 hammer.	1 small soldering iron.
1 wood chisel.	2 screwdrivers.	1 ratchet brace, with augers.
1 cold chisel.	2 bradawls.	1 detector.
1 long brick drill.		

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For outdoor work. The following additional tools will be required:—

1 draw-vice and key.
1 large pair of pliers.
1 12-inch half-round file.
1 firepot.
1 large soldering iron.
Bag of charcoal.
Portable battery, consisting of 3 smallest size Leclanché cells, fitted into a wooden box.

Soldering.

Too much importance cannot be attached to having good, well-soldered joints. The practice of twisting up the joints without a scrap of solder, though it may expedite matters in laying the wires, is too frequently the cause of a gradual falling off in the ringing power of the bells, due to increased resistance being thrown into the circuit by the rapidly deteriorating joints; which falling off in the ringing is at once put down by the inexperienced fitter as due to the exhaustion of the battery.

To make a good joint, the following method of procedure should be adopted:—Strip the ends of the wires to be joined of their insulation for a length of about 1½ inches, and scrape clean with a knife or brighten with emery paper. Then (taking one wire in each hand) twist the wires together as shown in Figs. 10 and 11 (Fig. 11 is a branch wire), and tighten up with the pliers. Now get ready the articles required for soldering, which should consist of the following:—A small copper bit, filed wedge-shape with an ⅛-inch groove cut across one face, as in Fig. 12; a small spirit-lamp for heating the bit, a stick of solder, and lastly, a piece of composite candle or rosin. The best "blow-pipe" solder should be used, the quality of which may be tested by holding it up to the ear and bending it, when, if it is good, a peculiar crackling noise will be heard, which is known as the "cry of the tin." To

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solder the joint, heat the bit, previously tinned, in a spirit-lamp or fire, and wipe with a piece of clean rag, and then, holding it with the grooved side upwards, fill the groove with solder. Now rub some composite candle or powdered rosin on the joint, and lay it in the groove, turning it over till the solder runs completely round, when quickly wipe with a piece of rag, and the result will be a strong, clean joint.

FIG. 10.—JOINING TWO WIRES.

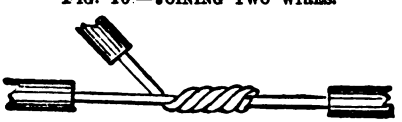

FIG. 11.—JOINING-ON A BRANCH WIRE.

This method will, in most cases, be found the best for small wires, as the practice of using a blow-pipe, unless great care is taken, generally ends in either melting the insulation so that it runs on to the joint, entirely preventing good work, or else in setting the insulation on fire on both sides of the joint. In

FIG. 12.—SOLDERING-IRON.

soldering, never use *spirits*, as with the small wires here referred to the corrosion that takes place will (especially in damp places) rapidly eat the wire asunder. Care must be taken in stripping the insulation from a wire that the wire itself is not nicked, for if this is done it will readily break at this point if bent at any future time. The insulation should always be removed by drawing the blade of the knife parallel with the

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wire, and not by cutting through the insulation at right angles, as this will most certainly nick it.

Insulating Joints.

All the joints, after having been soldered, must be thoroughly insulated. The importance of this is frequently overlooked, causing serious trouble afterwards, that might have been spared by a little attention in insulating the joints.

Joints, both in electric bell and also in electric light wires, are now insulated with pure rubber tape in preference to Chatterton's compound, as was formerly employed. The following materials must therefore be procured:—A roll of ½-inch pure rubber tape, a small tin or india-rubber solution, and a roll of ½-inch prepared tape, this latter being ordinary tape served on one or both sides with an insulating compound.

To insulate a joint proceed thus:—Cut off a length of about 2 inches of the rubber tape, and having warmed it over a lamp or candle, proceed to wrap it tightly round the joint, taking care not only that each turn overlaps the preceding one, but also that it joins well with the insulation on each side of the joint. Now dip the tip of the finger into the solution and smear the surface of the wrapped joint with a *thin* layer, after which the joint is finished off with a layer of the prepared tape.

Greater care must be taken when insulating a joint in wires laid underground or in exposed places, two or three layers of the pure tape being necessary, and the outside should be covered with Stockholm tar. Making a good insulated joint, however, in an underground wire, that will show high insulation and stand for any length of time, is an art in which few attain perfection without having had considerable practice in such work.

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CHAPTER II.

PUSHES, PULLS, AND SWITCHES.

PUSHES can now be obtained in almost every conceivable design and shape, and as the principle on which they act is the same in all, nearly everything in their selection will depend on personal taste and the decoration of the rooms in which they are to be fitted.

Fig. 13 shows a section of the ordinary electric bell push, the action of which is briefly as follows :—On the button being

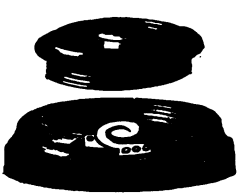

FIG. 13.—ORDINARY PUSH.

FIG. 14.—MORSE KEY PUSH.

pushed in, it causes the two German silver springs, hitherto kept apart by their own tension, to come together and make electrical contact between the two parts of the interrupted circuit, and on the pressure being removed the button and springs at once resume their former positions. The cover can be easily removed by unscrewing, thus allowing ready acces- for joining up or inspection.

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Another form of electric bell push, known as the Morse key or "double-contact" push, is shown in Fig. 14. This form of push is necessary where it is required to be able to signal both ways, using only one "line" wire and "earth" return. Referring to Fig. 14, the contact spring is, it will be seen, fitted with two contacts, one above and one below. In its normal position the spring presses against the top contact, but on the button being pressed, moves away from the top contact and is put into connection with the bottom one.

Pushes are made in wood, china and brass, the two former being chiefly employed for inside work, while the latter are mostly designed for fixing in exposed positions, such as at the front and back doors.

Another pattern Morse key push is shown in Fig. 15. In this form a spiral spring is fixed underneath the push button,

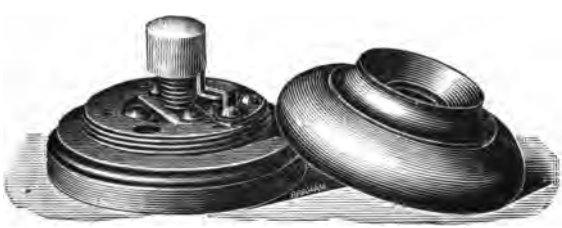

FIG. 15.—MORSE KEY PUSH.

keeping the button forced outwards, and the contact piece attached to it in contact with the top stop seen to the right of the figure. When the button is pressed in against the pressure of the spiral spring, the contact piece leaves the top stop and makes connection with the bottom one, putting the carbon pole of the battery to "line.'

Sometimes a Morse key, Fig. 16, is preferred to the double contact push. The action of the Morse key is similar to that

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of the double contact push. The horizontal lever, which is pivoted at its centre, is, when at rest, kept in contact with the

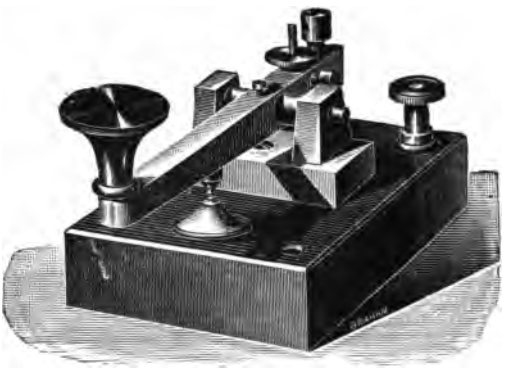

FIG. 10.—MORSE KEY.

back stop; but when the ebonite knob is pressed, the lever breaks with the back and makes contact with the front stop.

Wood Pushes.

Wood pushes are made in various shapes and patterns, the most common form being that shown in Fig. 13. Four other more ornamental patterns are shown in Figs. 17, 18, 19, and 20. The most usual sizes of pushes, whether wood, china or brass, are 2½ inches and 3 inches, this being the diameter across the widest part of the base. The 3 inch is the size now generally erected, since it has a better appearance and is but very little dearer than the 2½ inch.

Wood pushes are generally divided into two qualities, the first comprising pushes made out of ebony, cocus, rosewood, walnut, mahogany, &c., while the second consists of pushes turned from beech, cherry, maple and other woods, either ebonised or stained to represent the harder woods.

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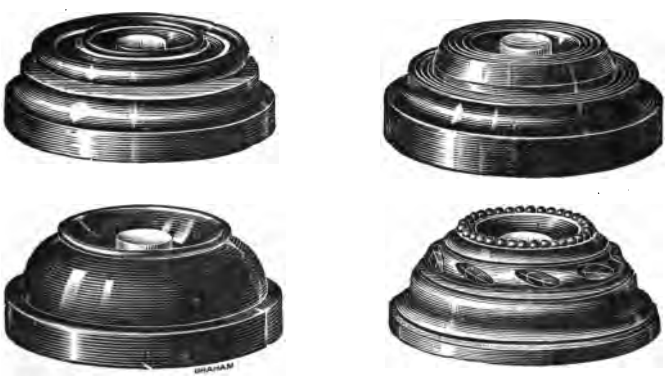
The springs of all pushes are generally made of German silver, the contact points in the best quality being tipped with silver or platinum. In selecting a good wood push, the main point to be looked to is, of course, that it has a well-finished and well-polished surface, after which the inside should be carefully inspected. The top springs should maintain a firm pressure against the bottom of the button, and when pressed, should not lose its set. A common defect with many hard wood pushes, is the case with which the screws holding the ends of



FIGS. 17–20.—VARIOUS PATTERN WOOD PUSHES.

the wires are overturned, owing to the screws being too small to bear the turning necessary to get good contact. The screws holding the ends of the wires should be a couple of sizes larger than those only securing the springs, and should be provided with a small metal washer, under which the better to clamp the wire. Some best quality pushes are fitted with screws having a metal thread, the hard wood being tapped to receive them. Pushes provided with these metal screws are less liable to be troubled with overturning, though it may be

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as well to mention that even with wood screws and a push of soft wood, overturning can easily be prevented with a little care.

China Pushes.

Pushes having a porcelain or china cover and button are known as china pushes, and are used chiefly in the same sizes as the wood, viz. 2½ and 3 inch. The covers of these pushes have a screw-thread moulded in them, into which screw the bases or backs. These backs are usually of oak (the springs being fixed to the base as in wood pushes), but can be obtained in ebonite at slightly increased prices. A push with an ebonite back has of course a better insulation, but it is doubtful if this is much advantage, except in specially damp situations. Like wood pushes, the springs are of German silver, with platinum or silver contacts in the best qualities.

It is owing chiefly to the immense variety of decorated patterns that the china push is so often used in places where from many reasons a good wood would be more suitable. With the high standard to which china and porcelain decoration has been brought, china pushes can be obtained in an almost endless variety of colours and patterns. Some of the more favourite designs are shown in Figs. 20 to 25. Fig. 22 shows the most common form, the cover being plain white, black or cream. The first advance in the way of decoration is by relieving the plainness of the cover and button by four or five gold lines. This sets off the push wonderfully, and it is very doubtful whether in the majority of cases any more suitable push can be obtained than white, cream or black, relieved with gold lines. These pushes will go with almost any style of decoration, and next to the plain white or black, are the most used. Fig. 23 shows a plain white push relieved with gold lines and fleur-de-lys, a style of decoration that makes a very

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handsome push. Fig. 24 is another effective pattern, consisting of a flower pattern in two or three colours on a white ground. Fig. 25 is a black pattern relieved with a gold flower.

In fixing wood and and china pushes, which should not, of course, be done till the building is quite finished, the push (the cover having been previously removed) is screwed to the bevelled wood block referred to in Chapter I., the two wires being brought through the hole in the base and fastened to

FIGS. 22-25.—VARIOUS PATTERN CHINA PUSHES.

their respective screws, care being taken to scrape the ends quite clean, and fasten them firmly down on to the springs by tightening up the screws. In places where the push has to be fastened to laths and plaster, the wall must be probed with a fine instrument to find the laths, and the push firmly screwed on by fine pointed lath screws.

A form of china push has recently been devised by the different manufacturers, in which the base as well as the cover are of china or porcelain. A screw-thread is moulded in the base, into which screws the cover, similar to an electric light

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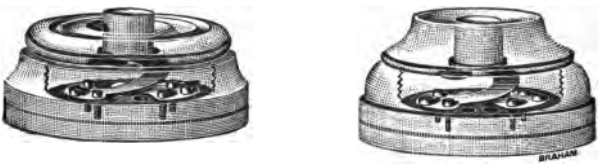
switch. The springs are secured to the base by metal screws, for the threaded portion of which the base is tapped, as shown in Figs. 26 and 27, which show two forms of these pushes.



FIGS. 26, 27.—PUSHES WITH BOTH BASE AND COVER OF CHINA.

Owing to their higher insulation and their freedom from wooden backs expanding and breaking the china, or shrinking and falling out, these pushes should come largely into use.

Table Pushes.

Table pushes are pushes adapted for standing on the desk or table, for which purpose they are usually weighted at their base with lead, to keep them from being easily tipped over,

FIGS. 28, 29.—TABLE PUSHES.

and also that they may serve as letter weights. They are connected to the wiring on the walls by a short length of two-

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strand flexible cord, the junction between the wires and flexible cord being made in a rosette fixed on the wall. Fig. 28 is a single-button table push of fluted brass, while Fig. 29 is a two-button one in carved walnut wood. Fig. 30 shows what

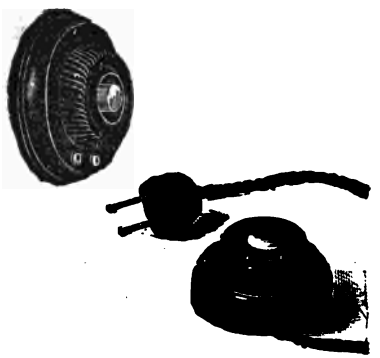

FIG. 30.—EXTENSION PUSH.

is known as an extension push, which will be found very convenient in places where it is wished to be able at times to extend the communication from the push on the wall to one on a table or desk. The extension push, which is on the left of the illustration, is, it will be seen, fitted with two plug-holes, into which the two-pronged plug connected to the table push can be inserted at will.

Flange Adapters.

Most pushes, whether of wood, china or brass, can be greatly improved in appearance, and made to look more massive, by the use of a brass flange adapter, three forms of which are shown in Figs. 31, 32 and 33. The push is slipped into the centre of the adapter and screwed up to the wall, the pressure

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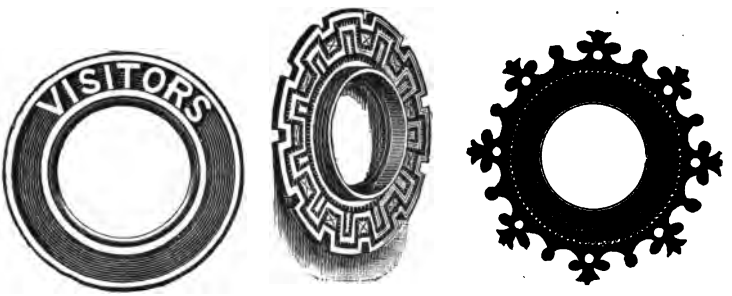
of the push against the wall holding the adapter in place. Thus, when fixed, the adapter appears part of the push, and



FIGS. 31–33.—FLANGE ADAPTERS FOR PUSHES.

the polished and lacquered brass work greatly enhances its appearance.

Pear Pushes.

Pear pushes are mostly employed for bedrooms, there usually being one fixed on either side of the bed after the manner of the ordinary crank bell-pull. This arrangement is

FIG. 34.—ROSETTE.

found more convenient than fixing a push on the wall, while if the pear pushes are properly arranged, it has also a neater appearance. The pear push consists of a pear-shaped handle,

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from the top of which projects the button, the internal arrangement of springs being similar to the ordinary push described at the beginning of the chapter. Connection is made to the wires on the wall by a two-strand silk cord, the junction being made inside the rosette. Fig. 34 shows the rosette with cover removed, and Fig. 35 the pear push and rosette complete. Pear pushes and rosettes are, like the best quality wood pushes, generally turned out of ebony, cocus, walnut, or rosewood, though a cheaper quality is to be obtained, made from softer woods, stained or ebonised. Fig. 36 shows a form of the pony push, or invalid pressel. This pressel is connected, like a pear push, to a rosette on the wall, the pressel being laid on the bed within easy reach of the invalid. The springs of these pressels are made specially weak, so that the button operates with the slightest pressure.

FIG. 35.—PEAR PUSH AND ROSETTE.

Pull Boxes.

Sometimes pull boxes are preferred to an ordinary pear push, owing to the trouble that sometimes arises from the flexible wire breaking, caused by people jerking the pear push, thinking it is an old crank bell. The action of a pull box is similar to the crank bell pull, the cord giving when it is pulled, and causing a sliding brass piece to join two metal contact springs. On the pressure being released a stout spiral spring pulls back the sliding-piece into its normal position. There

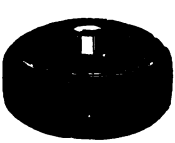

FIG. 36.—INVALID PRESSEL.

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are two kinds of pull boxes, the "straight" pull and the "lever" pull. In the former the sliding piece moves straight down, while in the latter it is fixed on the side of a lever, the end of which projects out at the side of the box.

FIG. 37.—PULL BOX.

FIG. 38.—STRAIGHT PULL.

FIG. 39.—LEVER PULL.

Figs. 37 and 38 show the straight pull, and Fig. 39 the lever-pull. The form shown in Fig. 38 is a reeded brass, while Fig. 39 is a cheaper pull box in polished walnut.

Brass Pushes.

Brass pushes, owing to their being fixed chiefly at front and back doors and other exposed positions, are more substantially made, and mostly designed so as to be watertight. A simple form, and one largely employed, is shown in Fig. 40. In this form the back is of wood or ebonite, on which are fixed the two contact springs, the back screwing into the metal cover similar to china pushes. Fig. 41 shows another inexpensive form, and one much used for side door and tradesmen's entrances,

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owing to its being narrow and thus easily fixed in the wood framework of the door.

The pushes chiefly employed for exposed positions, how-

FIGS. 40, 41.—SIMPLE FORM BRASS PUSHES.

ever, are known as the "barrel," three forms of which are shown in Figs. 42, 43, 44, The contacts of these pushes are

FIG. 42.—SHORT BARREL PUSH. FIGS. 43, 44.—LONG BARREL PUSHES.

arranged inside a brass barrel, which is rendered as watertight as it is possible to make it. One contact is arranged at the

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back of the barrel, while the other is on the end of the press button, which is kept pressed out towards the front of the push by a spiral spring. Owing to this employment of a spiral spring, the motion of the button when pressed is much more agreeable

FIGS. 45, 46.—FANCY BRASS PUSHES.

than that of the ordinary push, in which the button has a tendency to move on one side in addition to its proper motion. Figs. 45 and 46 show two forms of fancy brass pushes, these pushes being intended for inside work.

Pulls.

Pulls are preferred by many people, for front and back entrances, to pushes, owing to their more massive appearance, and from the fact that they are better able to stand rough usage. Fig. 47 is a side view of the ordinary electric bell pull, showing the two springs and contact piece. The two springs seen at the top and bottom are insulated from the metal frame by a block of ebonite or vulcanised fibre, and on the knob being pulled out are electrically connected by the insulated metal disc at the end of the rod. This metal disc is kept pushed out beyond the ends of the metal contact springs by the spiral spring shown. Another form of pull, known as the quadrant pull, is shown in Fig. 48. It consists of a metal quadrant working on a pivot at the bottom of the base, the centre of the quadrant being provided with a horizontal arm

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which makes contact, when the handle is drawn down, with two springs at the top of the base. For both these forms it is

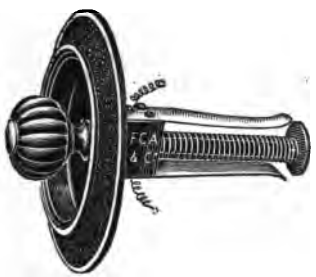

FIG. 47.—ORDINARY PULL.

FIG. 48.—QUADRANT PULL.

FIG. 49.—FANCY PULL.

necessary when fixing to cut away the woodwork of the door frame to allow the spring part to project through.

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Fig. 49 shows a fancy pattern of the ordinary form of pull, and Fig. 50 another form of lever pull adapted to work with a rod outside. Like brass pushes, all pulls are to be obtained in

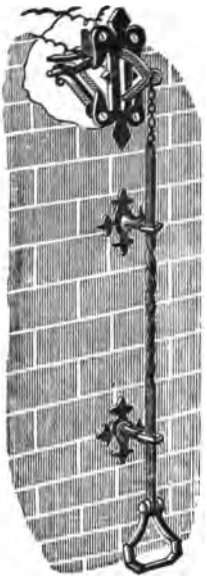

FIG. 50.—LEVER PULL.

FIG. 51.—NAME PLATES FOR PUSHES.

polished brass, bronzed or bronze relieved. Fig. 51 shows a form of name plate usually employed with front door pushes and pulls, the plates being fixed round the circular part of the push.

Switches.

Switches are required in electric bell work, either for making or breaking a circuit or for transferring pushes and contacts from one circuit to another. The forms most used in electric bell work are those shown in Figs. 52, 53 and 54, the more complicated ones being but rarely used. Fig. 52 shows the most common form, this pattern being made from one-way up to six-way. The one shown in the illustration is a two-way switch. When the handle is put to the left the current is sent in one direction, and when put to the right, in another, while, when between

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the two, both circuits are broken. Fig. 53 shows the circular form of this pattern switch.

A form of the plug switch or interrupter is shown in Fig. 54. When the plug is in the hole the two brass plates are

FIG. 52.—TWO-WAY SWITCH.

FIG. 53.—CIRCULAR PATTERN SWITCH.

FIG. 54.—PLUG SWITCH.

joined and the circuit is complete, but on withdrawing the plug the circuit is broken again. By fixing on more plates and boring more plug holes these switches can be made for operating one, two, three, or any number of circuits.

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CHAPTER III.

BELLS AND RELAYS.

It is of the highest importance in selecting a bell, to see that a really substantial and trustworthy article is obtained. All the best bells are now mounted on an iron frame, independently of the wooden base, so that the working of the bell is quite unaffected by warping of the base, should such occur. Uncovered bells should never be used, on account of dust getting into the contacts, and bells fitted with box-wood or vulcanised fibre bobbins are much to be preferred to those with metal ones. All contacts should be made of platinum; and if platinum is paid for, care should be taken to see that it is really obtained, as a white metal, such as German silver, is sometimes substituted.

The Vibrating Bell.

The form of bell most frequently used is the trembling or vibrating bell (Fig. 55), which consists of an electro-magnet firmly fixed to an iron frame, and provided with a soft iron vibrating armature, one end of which is fitted with a hammer, and the other fixed to the iron frame by a spring *a*, the lower end of which carries a platinum contact. Fixed to the iron frame, but insulated therefrom, is a contact post *b*, fitted with an adjustable platinum-pointed contact screw, and a tightening screw, which latter, when screwed up, entirely prevents the adjustable screw working loose, as it has a great tendency to do.

The action of the bell is as follows:—The current, entering at the terminal L, flows round the coils of the electro-magnet,

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and thence by armature and contact spring, to platinum-pointed contact screw, contact post, and thence to terminal Z. But in thus flowing round the coils of the electro-magnet, the current has magnetised the cores, which now attract the armature, causing it to move up to the poles, bringing with it the hammer, which is impelled against the gong, while at the same time the contact spring moves away from the contact screw, thus breaking the circuit. As the cores of the electro-magnet are made of soft iron, all magnetism now practically ceases, and the armature, in obedience to the contact spring, moves back into its former position, only to repeat the previous operation so long as the button of the push is kept in.

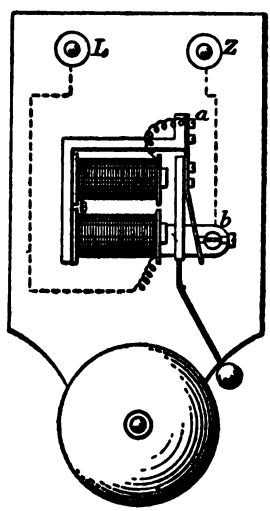

FIG. 55.—VIBRATING BELL.

To adjust a trembling bell it will be necessary to first make sure that all the connections are tight; then, holding the hammer against the gong, slacken the tightening screw, and screw up the adjustable screw till the platinum point is just clear of the contact on the spring. Then let go the hammer and see if the spring draws the armature back so as to make good contact, and if this is so, tighten up the set screw. See also that the armature, when attracted, does not touch the poles, or there will be a tapping sound while the bell is ringing. If the contact screw is screwed up too far, the spring will not break contact with it, while if is not screwed up far enough the sound will be feeble, since the hammer will not reach the gong with much force. Sometimes a bell rings

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badly from the spring either setting the armature back too strongly, or from being so weak that it does not bring it back with sufficient rapidity. To find out which is the true cause, take a piece of wire, or better still, a piece of watch spring, and whilst the bell is ringing press the armature towards the poles; then if the ringing is improved the spring is too strong, and must be taken off and set a little inwards. If, on the contrary, the ringing improves when the armature is pressed away from the poles, the spring is too weak, and must be set a little outwards.

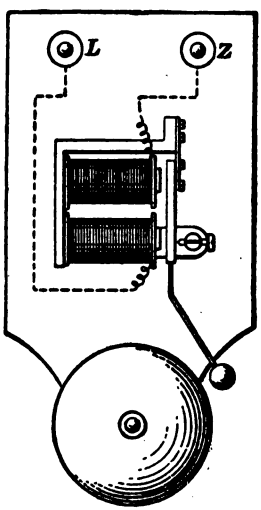

FIG. 56.—SINGLE-STROKE BELL.

The Single-Stroke Bell.

In many cases communication is desired between two places by means of certain pre-arranged signals, such as a certified number of strokes of the bell. For this purpose the single-stroke bell, a form which is shown in Fig. 56, must be used. This is the electric bell in its simplest form, consisting of an electro-magnet, an armature and a stop-screw, to prevent its being moved too far back from the poles. When the push is pressed, the electro-magnet draws up the armature, striking the hammer against the gong, and retaining it there so long as the circuit is closed; but on the circuit being broken, the armature moves back into its normal position, which is, resting against the stop-screw. A stroke of the bell is thus obtained each time the button is pressed.

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To adjust a single-stroke bell so that a clear sound is obtained, push the armature up to the brass studs which are driven in the ends of the poles, then bend the rod so that the hammer is just clear of the gong. Now let go the hammer, and adjust the stop-screw till the best effect is obtained. If the hammer touches the gong before the armature reaches the stops a harsh sound will be produced, owing to the hammer stopping the vibration of the gong.

The Short-Circuit Bell.

It is very often desired to place two or more bells in series on one circuit. If the bells are single stroke no difficulty presents itself, but on attempting to do this with the ordinary trembling bell, the ringing becomes at the best very indifferent and spasmodic, arising from the fact that as the bells are not exactly similar, they do not make and break the circuit in unison. One way of getting over this difficulty is to have one of the bells a trembling bell and the rest single-stroke, the trembling bell governing the vibrations of the single-stroke; but even when arranged thus, unless the bells are very much alike, the ringing is rarely satisfactory. Perhaps the best plan is to use the form of bell shown in Fig. 57, which, as will be seen from the figure, governs its vibrations, not by breaking the circuit, but by "shunting" its coils. On the current flowing round the electro-magnet, the armature is attracted, and the

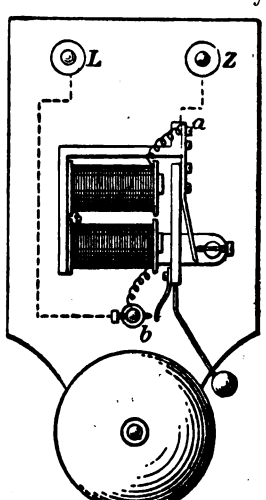

FIG. 57.—SHORT-CIRCUIT BELL.

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spring makes contact with the screw *b*. There now exists a path from *a* to *b* of practically no resistance; the current, therefore, is diverted from the magnet coils, and passes by the armature and screw *b*, to the next bell, the armature falling back against the stop-screw and repeating the previous operation so long as the circuit is closed. Thus, no matter how many bells there may be in the series, the circuit is never broken. This form of bell, however, does not ring so energetically as the ordinary form, with a corresponding amount of battery power. No difficulty will be experienced in arranging two or more bells (either trembling or single-stroke) in parallel on the same circuit, so long as care is taken to provide sufficient battery power.

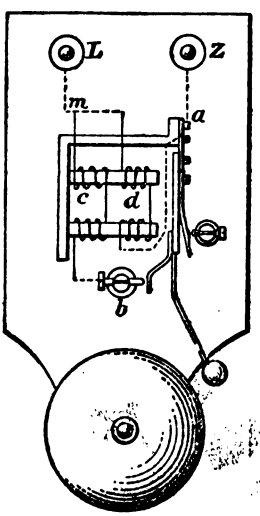

FIG. 58.—DIFFERENTIALLY-WOUND BELL.

The Differentially-wound Bell.

Another form designed for working in series is that known as the differentially-wound bell, a form of which is shown in Fig. 58. As regards its arrangement of parts, it is similar to the short circuit form just described, but differs from it in respect to its magnets, which are wound with two coils, the one, *c*, in an opposite direction to the other, *d*. On the current entering at the terminal L the action of the bell is as follows:—Starting from terminal L, it passes through the coil *d* to the screw *a*, and thence to terminal Z. The circuit of coil *c* being open, the iron cores are magnetised by the current in the coil *d*; thus the armature is attracted, and makes contact

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with the contact post *b*. This closes the circuit through the coil *c*, which neutralises the magnetism imparted by the coil *d*, and the armature falls back against the stop-screw, only to repeat the previous operation. This form of bell is almost sparkless at its contact.

Speaking of this method of winding, Professor Sylvanus Thompson, in his lectures on "The Electro-magnet," delivered recently before the Society of Arts, says:—"When equal currents flow in both circuits there is no magnetism. If you break the circuit of either of the two coils the core at once becomes magnetised. You get magnetism on breaking, you destroy magnetism on making the circuit; it is just the inverse case to that of the ordinary electro-magnet. There the spark occurs when the magnetism disappears; but here, since the magnetism disappears when you make the circuit, you do not get a spark at make, because the circuit is already made. You do not get any at break, because at break there is no magnetism.'

In actual practice, however, these bells work rather sluggishly, and like the short-circuit bell require more battery power than the ordinary vibrating form.

Continuous-Ringing Bells.

Very often, as in connection with a system of burglar alarms, &c., a bell, when once started, is required to ring continuously. For this purpose what is known as a "continuous-ringing" bell must be employed. The most general form of this bell is shown in Fig. 59, the construction of which is similar to the trembling bell just described, but with this addition: the lower end of the armature is fitted with a catch which engages with a lever, to which is fixed a spiral spring, the tension of which can be regulated by a milled nut. An extra contact post *d*, and screw, fixed beneath the lever, is also provided. The action

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of the bell is as follows:—The current flows at first from terminal C to L, as in the trembling bell; but on the first stroke of the armature, the lever slips off the catch and falls against the contact screw *a*. The current now flows from terminal C, round electro-magnet to frame, armature, and upper contact post; thence to lever and lower contact post,*

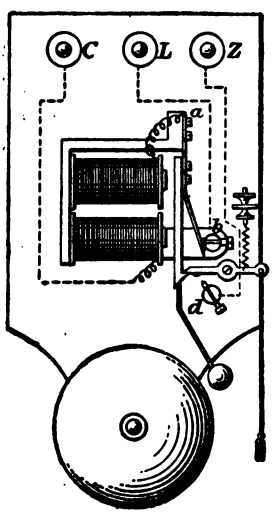

FIG. 59.—CONTINUOUS-RINGING BELL.

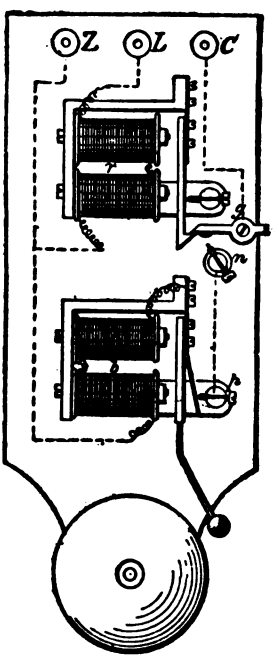

FIG. 60.—CONTINUOUS-RINGING RELAY BELL.

and then to terminal Z, the bell continuing to ring until a cord at the side is pulled, which breaks the circuit by resetting the lever.

* The upper contact post, *b*, is in connection with the lever, which connection is not shown in the figure.

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Another form of continuous-ringing bell, which is to be preferred from its being more certain in its action, is shown in Fig. 60. In this bell the lever is released, not by the bell armature, but by the armature of a relay fixed above the bell coils. On the push being pressed, the current entering at terminal L, passes through the relay coils *r* and out at Z. The relay armature being at tracted, releases lever *g*, which makes contact with *n*. The current now flows from terminal C, through the bell coils, to the frame armature A, and lower contact post *p*, by way of the contact post *n*, and lever *g*, and out by terminal Z; the bell continuing to ring until the lever is reset as before.

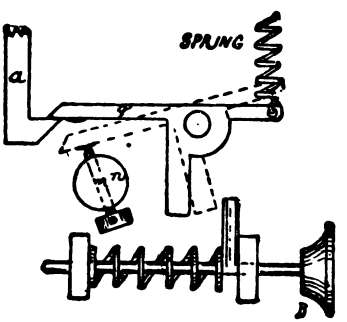

FIG. 61.—PRESS REPLACEMENT.

Fig. 61 shows a form of press replacement to be preferred to the cord when the bell is within reach, in which the lever *g* is replaced by pressing the button B.

In adjusting continuous-ringing bells, the movement is first adjusted as described on page 31 for the vibrating bell. The lever is then released and the tension of the spiral spring adjusted so that only such pressure is put on the lever as is sufficient for good contact. The more the tension, the greater the pressure on the lever, and more battery power is thus required to release it.

A form of continuous ringing bell, which, among its other advantages, can be reset from a distance, was introduced a few years ago, but this will be described subsequently, when the diagrams for connecting-up the bells, &c., are given, as its action will then be more readily understood.

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The external appearance of the different kinds of electric bells is of course very similar, the difference being almost solely in the movement. The base, which in the best qualities is of polished teak, walnut, or mahogany, has affixed to it either by

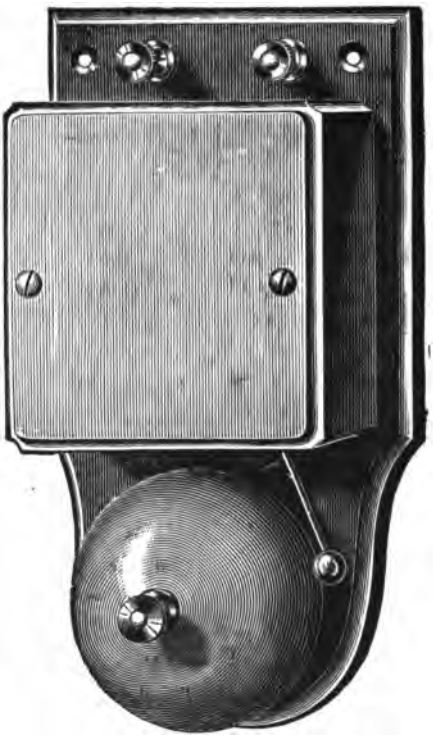

FIG. 62.—BEST QUALITY ELECTRIC BELL.

screws, hangers, or hooks, a substantial cover of the same wood which covers in the whole of the movement. The case is cut away at the bottom for the hammer to pass through, and also

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at the side in continuous-ringing bells for the lever. The terminals are fixed at the top of the base and the connections either run on the surface or let in at the back.

Electric bells are generally made in three qualities, viz. best, medium, and cheap, the difference being in the construction and finish of the movement, and finish and polish of the case, which is also more substantially made in the best quality.

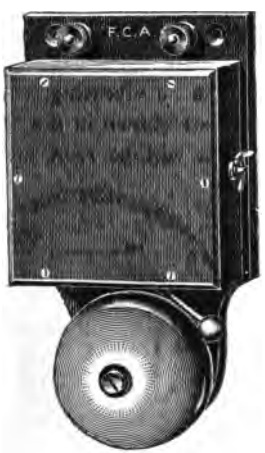

FIG. 63.—MEDIUM QUALITY BELL.

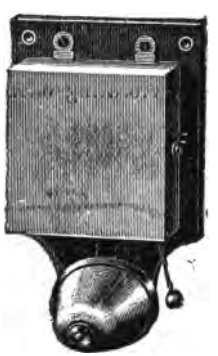

FIG. 64.—CHEAP QUALITY BELL.

Fig. 62 shows a best quality bell complete, with cover on, while Figs. 63 and 64 show the medium and cheap qualities. In the cheap quality bells the cases are usually of stained white wood, and have connecting plates instead of terminals.

The different sizes of electric bells are classed according to the diameter of their gongs, and are called 2, 3, 4, or 6-inch accordingly.

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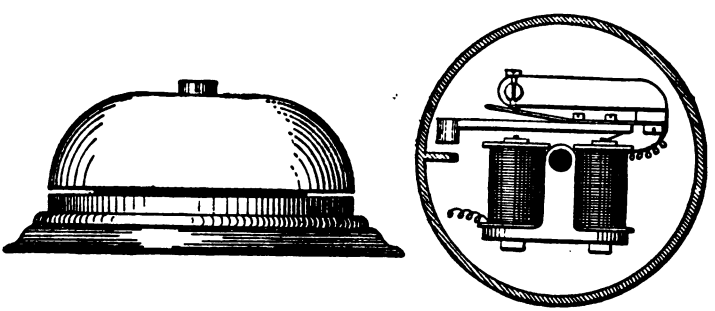
Circular Bells.

When a bell is so designed that the movement is all contained in the gong, it is known as a "circular bell," and when the gong takes the shape of a church bell it is known as the "church-bell" pattern.

Bells with the movement all contained within the gong are much used in electric bell work for mounting on top of indicators, &c. The form most usually employed is shown in Figs. 65 and 66, Fig. 65 being a side view of the complete bell, while Fig. 66 is a plan with the upper part of the gong removed. The movement can of course be vibrating, single-stroke, or short-circuiting, as desired, that shown in the figure being a vibrating one. The hammer, it will be seen, strikes



FIGS. 65, 66.—CIRCULAR BELL.

on a lug cast on the gong, while the gong is supported on a projecting arm of the iron frame. In the figure the bell is shown mounted on a special wooden base, as is the case when the bell is used separate, but if for an indicator it is mounted directly on the wooden base-board.

Fig. 67 shows another form of the circular bell, known as the "Shield," from the shape of its iron base. Fig. 67 shows

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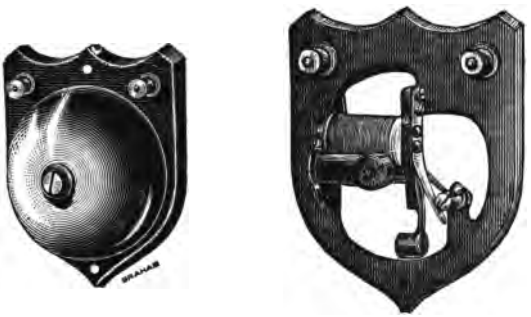
the bell complete, while Fig. 68 is a plan with the gong removed. Only one bobbin is employed, and the hammer



FIGS. 67, 68.—SHIELD BELL.

strikes, as is the case with the previously described form, on a lug on the inside of the gong.

Another form of bell with the movement inside the gong is shown in Fig. 69, the gong being of the church-bell shape.

69.—CHURCH-SHAPE BELL.

Of the variety of bells having the movement contained within the gong, the Jensen church-shape bell, owing to its neat appearance, the simplicity of its movement, and the purity of its tone—which, it would seem, is only to be obtained by this shape gong—is without doubt entitled to rank as one of the best.

Its general construction can be seen from Fig. 70. Inside the gong is placed a single magnet of special construction, the armature of which;

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besides being magnetised by induction, is directly polarised by being in actual magnetic contact with the iron core of the magnet; it is thus induced to perform a large amount of work with comparatively small power. P P are the poles of the electro-magnet E, to an extension of the core of which is fixed the armature A, pivoted at O, and in its normal

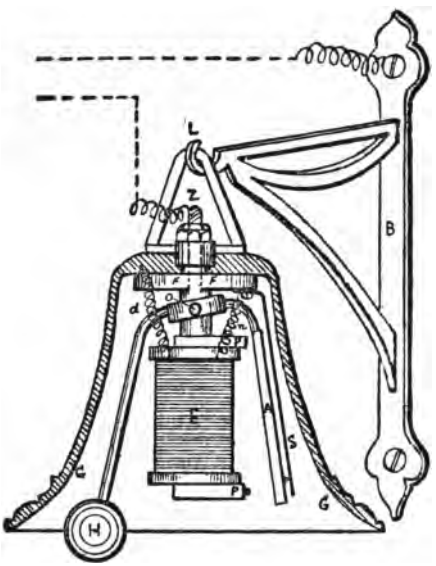

FIG. 70.—JENSEN ELECTRIC BELL.

position resting against the contact spring S. The bell is supported at L by the bracket B, which in practice becomes one terminal, the other being formed by the nut and screw Z, which carries the movement; the whole being insulated from the gong G by the insulating material F. The bell in the figure is shown connected-up as a trembling bell. If a single-stroke

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bell is desired, the wire, instead of being fastened to the spring S, is directly attached to the movement. On the button being pressed, the current flows by bracket B and loop L to the gong G; thence by wire *d* to magnet coils E, wire *n*, spring S, armature A, pivot O, leaving by terminal Z. In many instances the wire, instead of being taken directly to terminal Z, is fastened to a spring, one end of which is fixed to (but insulated from) the bracket B, and the other presses firmly on the top of the screw Z. Thus the bell can be readily taken off the bracket and replaced without disturbing any connections.

The bell shown in Fig. 69 is the most simple form of the Jensen bell, there being a pole-piece fitted to one of the poles of the electro-magnet only, the other being extended out through the core and gimbal to the armature, which thus exhibits opposite polarity to the pole at the bottom of the electro-magnet. The more expensive forms have two pole-pieces, one at each end of the bobbin, the armature being magnetically insulated from the electro-magnet by the extension of the core beyond the top pole-piece being made of brass. In the large-size bells the armature is wound in addition to the magnet, the coil on the armature being in a reverse direction to that on the magnet, the two coils being afterwards joined in series. In the more expensive vibrating bells, an arm, fixed to the box-wood base, and having at the lower end an adjusting screw, is employed, thus giving greater facilities for adjustment; though in the larger bells, where a vibrating action is desired, the inventor prefers to join up the bell as a single stroke, and insert a separate make and break in the circuit, which can be placed in any easily accessible and dry place.

Mr. Jensen has also given great attention to adapting his large bells for factories and use at Board Schools, in place of the usual method of ringing the bells by a rope. Several very large bells have been fitted up for these purposes, and the

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FIG. 71.—LARGE JENSEN BELL IN CLOCK TURRET.

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ringing has been all that can be desired. A separate clock-work make and break is used in conjunction with these large bells, by moving the adjustment of which the rapidity of the strokes can be varied to a nicety. Fig. 71 shows a big bell fixed on a bracket in conjunction with a clock, the clock causing the bell to strike the hours or ring continuously at intervals, such as is necessary in factories to give notice to the men for the cessation of work.

Mining and Outdoor Bells.

In mines and other places where the bell is exposed to excessive dampness, and perhaps direct action of the rain, the

FIG. 72.—MINING BELL.

ordinary form of electric bell, with wood base and cover, is of course useless, as the different parts soon corrode and perish.

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A specially solid form of movement is therefore made for mining bells, and the whole enclosed in a substantial cast-iron case, as shown in Fig. 72. The cover, which is also of cast iron, bolts on to the base against a rubber washer, so that the case is rendered waterproof. Thus these bells are often fixed in porches or railway stations where they are exposed to the direct action of wet.

Sets of Bells.

Sets of 3 or 4 bells of different tones, mounted on one board, are often preferred by many people to an indicator for small houses. The servant can, on hearing the bell, go at once to the room from which the signal has been sent, though of course this system is not applicable where the number of rooms is above six, owing to the difficulty of distinguishing the tones. Fig. 73 shows a set of three bells complete. The

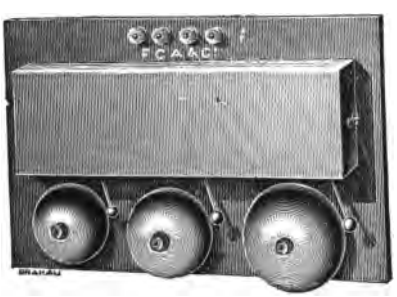

FIG. 73.—SET OF THREE BELLS.

bells, it will be noticed, are mounted on a backboard common to all, and are provided with a cover that slides over the whole of the movements. The difference in the tone is obtained by employing gongs of different diameters, and also by using gongs of special shapes.

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Like the separate bells, these sets are made in three qualities, best, medium, and cheap.

Continuous-Ringing Attachments.

Besides the methods previously described of making bells continuous ringing, there are several others that may be adopted. The indicator drops may be so constructed that they keep the circuit closed after the vane has fallen, or, what is preferable, where the bell is of large size or there are many bells to be rung at the same time, some arrangement, quite apart from the bell or indicator, the sole object of which is to keep the circuit of the bells closed after the push has been pressed or contact moved. These are known as "continuous-ringing attachments," a form of which is shown at Fig. 74.

The attachment consists, it will be seen, of the two electro-magnets *a a*, fixed to the iron frame *b*, the upper end of which carries the armature *c*, by means of the spring *d*. To the bottom part of the iron frame is fixed a brass post *e*, carrying the stop-screw *f*. This part of the attachment, it will be noticed, is similar to that of a single-stroke bell with the hammer removed from the end of the armature, and the catch *g* substituted in its place. Supported by the catch *g* is the contact-piece *h*, which, when released, impelled by the spiral spring *i*, swings round on the screw *k*, the platinum point *l* making contact with the platinum-tipped spring *m*, fixed to the upright support *n*. Below the contact-piece is the rod *o*, carrying at its lower end the button *p*, and working in the two supports *r r*. To the rod *o* is fixed the washer *t*, against which presses the spiral spring *s*, thus keeping the rod down.

The action of the apparatus is as follows:—When a current flows round the coils of the electro-magnet, the armature is

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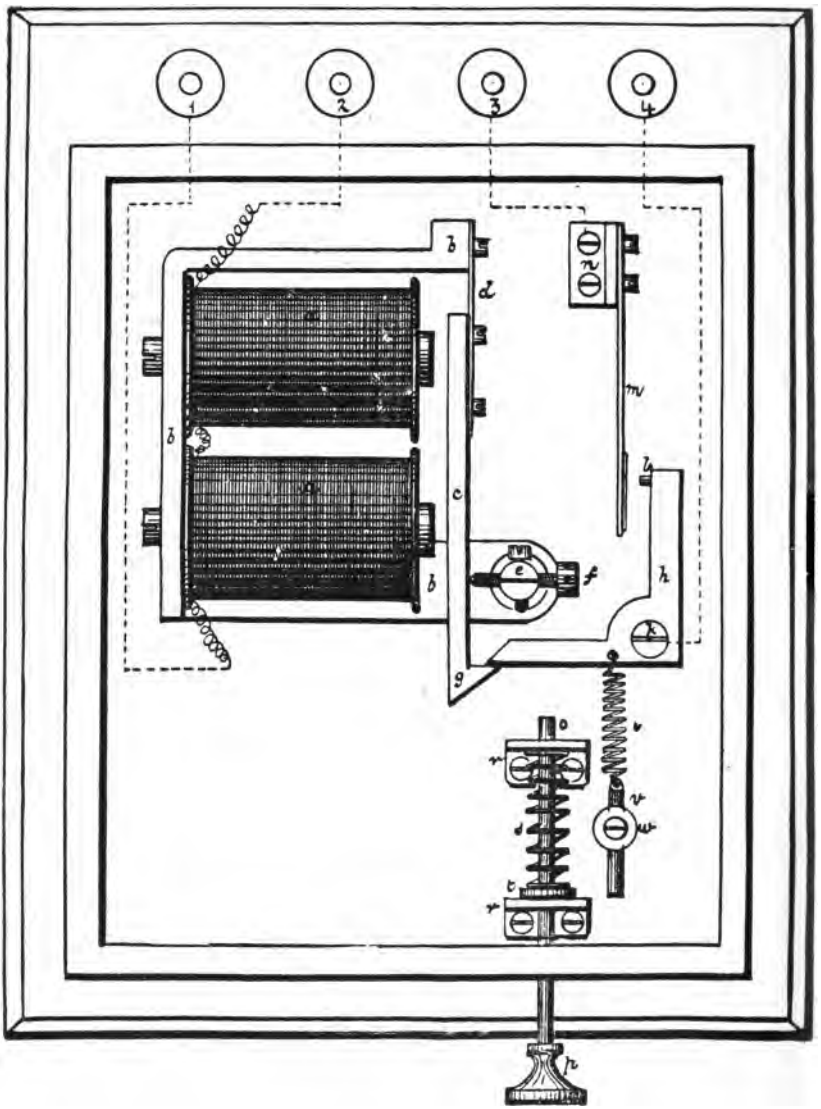

FIG. 74.—CONTINUOUS-RINGING ATTACHMENT FOR BELLS.

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attracted, releasing the contact-piece *h*, which, impelled by the spiral spring *i*, makes contact with the platinum-tipped spring *m*. This closes the local circuit through the bells, which continue to ring until the button *p* is pressed, causing the rod *o* to reset the contact-piece *h*, thus breaking the local circuit. By mounting the contact on the spring *m*, instead of on a rigid post, as is usually done, a "wiping" action is obtained in the contacts in place of a dotting one, which has a tendency to keep the surfaces bright; for when the piece *h* is released the platinum point *l* presses against the spring *m*, and the spring gives, causing the point to travel along the platinum surface of the spring for about an eighth of an inch, thus ensuring good contact.

Terminals 1 and 2 are connected into the "line" or main circuit, while terminals 3 and 4 are connected into the local circuit containing the bell or bells.

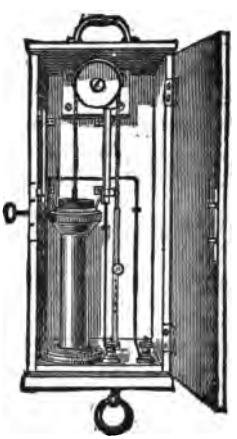

FIG. 75.—CONTINUOUS-RINGING ATTACHMENT.

An ingenious arrangement for closing and keeping closed the circuit of one or more bells for a certain time, has been devised by Mr. H. Thorpe. The arrangement is shown in Fig. 75. When the ring at the bottom of the case is pulled downwards, the plunger is drawn out of the tube, two springs on either side making contact with two rods fixed one on each side. This closes the circuit, causing the bell or bells to ring. The ring being released, the plunger slowly sinks into the tube, the bells continuing to ring until the plunger has sunk to the bottom, when the springs break contact with the rods, and open the circuit. By altering the position of the pin in the

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rod seen in the centre of the case, the length of time that the bells ring can be varied from 5 to 30 seconds.

The Magneto Bell.

Very often, in signalling between two places that are far apart, it is preferable, owing to the high resistance of the circuit, to employ a magneto bell and generator instead of a battery; for when the battery consists of many cells the expense becomes an important item, and there is, in addition, the bother of keeping so many cells in order. The magneto generator is generally constructed to furnish its current at a high E.M.F., such as is required on a high resistance circuit; and in telephony magnetos are used that will easily ring a bell through a resistance of 6000 to 10,000 ohms. In large buildings, too, it is frequently desired to fit up an extra bell from one part to another without having to run wires to the battery, which may happen to be a long way off, and it is here again that a magneto may be employed to advantage.

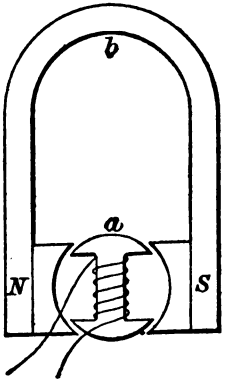

FIG. 76.—MAGNETO GENERATOR.

The apparatus required for signalling by the method mentioned above consists of two parts—the generator and the bell. The principle on which the generator acts is the same as that on which is based the action of all dynamos, and, in fact, the generator finds in the dynamo almost its exact counterparts. The action of the generator will be readily understood by reference to Fig. 76, which shows its two principal parts, the armature (*a*) and the permanent magnet (*b*). The armature

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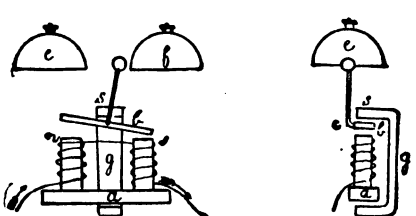
consists of an iron shuttle, on which is coiled fine silk-covered copper wire. Now Faraday discovered, *that by moving a wire or other conductor near the pole of a magnet, in such a manner as to cut lines of force, a current of electricity is generated in that wire.* Thus, when the armature *a* is made to rotate rapidly between the poles of the magnet *b*, a current of electricity circulates in its coils, the direction of the current being reversed at each half revolution of the armature. We see, therefore, that the current from the generator flows first in one direction and then in the other; the rapidity of the alternations depending on the speed at which the armature is rotated.

This alternating current is not adapted for working the ordinary form of electric bells, as these are designed to work with a current that flows always in one direction, such as is given out by a battery; so a different form of bell is used. The action of the magneto bell, which is somewhat more complicated than the ordinary form, will be better understood by a glance at Figs. 77 and 78. Fig. 78 is a side view of



FIGS. 77, 78.—MAGNETO BELL.

Fig. 77. It will be seen that the bell consists of an electro-magnet *a*, opposite the two poles of which is pivoted at *c* the soft iron armature *b*. From the centre of this armature springs the hammer *d*, which works between the two gongs *e* and *f*.

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By the side of the electro-magnet *a* is placed a permanent magnet *g*, the pole N of which comes near the armature *b*, and the pole N near to the bottom yoke of the iron cores of the electro-magnet. The effect of this is, that the south pole S of the permanent magnet magnetises by induction the soft iron armature *b*, causing it to exhibit north polarity on the side nearest to the permanent magnet, but a strong south on the other. The north pole of the permanent magnet similarly magnetises the iron cores of the electro-magnet, the poles of which thus exhibit north polarity. When, therefore, no current is flowing round the electro-magnet, both ends of the armature are attracted alike, and the hammer will remain against either gong if once placed there. If, now, a current from the generator flows round the electro-magnet *a* in the direction shown by the arrows, the left-hand pole becomes north and the right-hand south; the north pole powerfully attracting one end of the armature, and the south pole repelling the other, throwing the armature over into the opposite position shown, which causes the hammer *d* to strike the gong *e*. When, at the half revolution of the generator armature, the direction of the current is reversed, the right-hand pole *b* becomes north and the left-hand south, throwing the armature over into the position shown, which causes the hammer *d* to strike the gong *f*. As the armature of the generator is rotated very quickly, the reversals of the current are very rapid, and the ringing becomes similar to that of the ordinary electric bell. In the earlier forms of this bell the armature, instead of being made of soft iron, consisted of a permanent magnet, the construction of the bell being similar to that of a polarised relay. Thus, when the current from the generator was sent round the electro-magnet, its armature was alternately attracted and repelled, throwing the hammer first against one gong and then against the other. This form of

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bell had many defects, the chief of which were its sluggish action, and the inability of the hammer to strike the gong with sufficient force to give out a loud sound. The substitution, however, for the polarised steel armature of a soft iron one, inductively magnetised by a permanent magnet placed in close proximity to it, effected a great improvement in the bell, at once quickening its action and increasing its range.

As magneto bells are generally only used where it is desired to be able to signal both ways, the bell is usually combined in

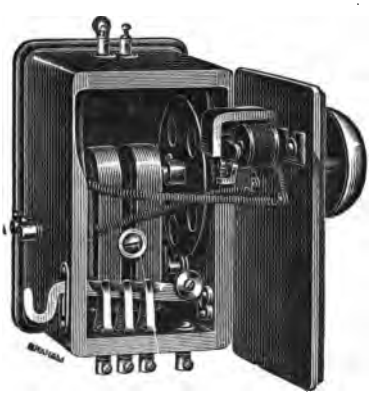

FIG. 79.—SMALL MAGNETO GENERATOR.

the same case as the generator. Fig. 79 shows a small generator of this pattern, there being also a switch-hook at the bottom, since the generator is mainly intended for telephony, which is the chief field of the magneto bell. The generator is, it will be seen, fixed in the body of the case, while the bell is on the lid. The hammer-head, projecting through a hole, works between the two gongs. Fig. 80 shows a more powerful magneto generator and bell, such a combination being capable of signalling between London and Edinburgh.

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The armature of the generator having a high resistance, it became a necessity (to avoid having always to ring through this resistance) to have some means of cutting out the armature when the generator was not in use. This was formerly done with a key, but an improved method has been subsequently introduced, by means of which the armature, when at

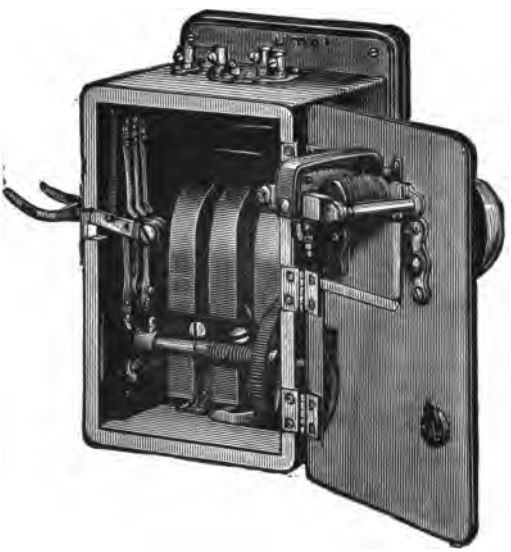

FIG. 80.—POWERFUL MAGNETO GENERATOR.

rest, is bridged across by a low resistance circuit, but any movement of the handle in either direction at once breaks this circuit, throwing the current of the generator to "line." Fig. 81 shows this arrangement in detail. The spindle *a*, running in the bearings *b* and *b'*, carries at one end the handle *g*. The driving wheel *e* is loose upon this spindle, but is prevented from slipping round by the pin *f*. This pin fits

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into a V-shaped notch in the collar *h*, which is part of the wheel *e*. A collar *c* is secured to the spindle *a*, and inside this is the spiral spring *d*, which, thrusting against the bearing *b'*, keeps the end of the spindle in contact with the spring *m*. So long as the end of the spindle presses against the spring *m* the armature is short circuited, but when the handle *g* is

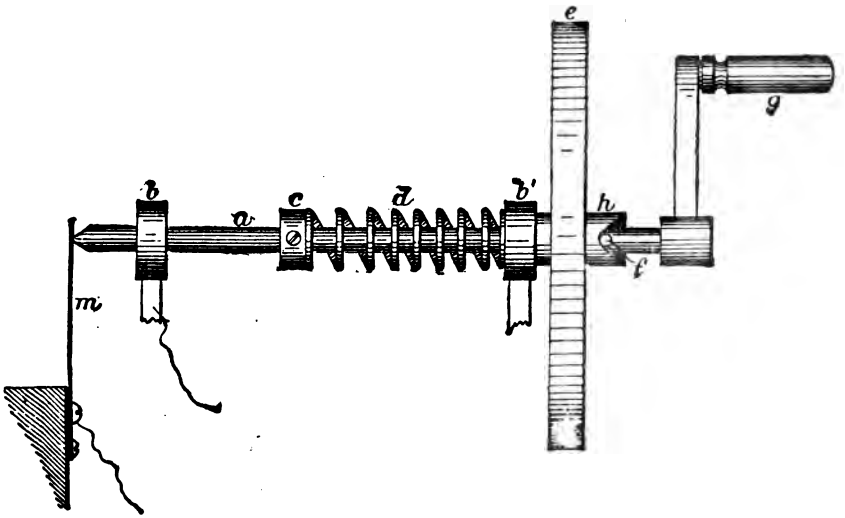

FIG. 81.—ARMATURE SHUNT OF MAGNETO GENERATOR.

moved, the pin *f* rides up in the V-shaped notch in the collar *h*, drawing the spindle away from the contact spring *m* against the pressure of the spiral spring *d*, thus breaking the circuit.

Figs. 82 and 83 show the form the magneto bell usually takes when not combined with the generator. *a a* are the two electro-magnets, opposite the poles of which is the armature *b*. The hammer *c* is joined to the armature at the pivot *d*; *e* is

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the permanent magnet, fastened to the brass piece *f*, which also carries the armature; the distance of the armature from the poles of the electro-magnet being adjusted by the nuts *g*.

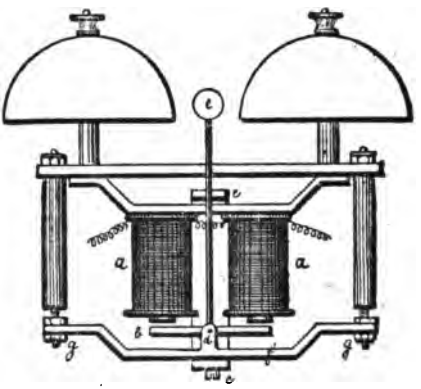

FIG. 82.—MAGNETO BELL UNMOUNTED.

FIG. 83.—MAGNETO BELL COMPLETE.

The bell is enclosed in a polished wood case, as shown in Fig. 83.

Magnetos require but little attention to keep them in order:

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a few drops of oil now and then in the bearings of the generator, and the armature of the bell may require a slight adjustment from time to time. Unlike the ordinary electric bell, however, there are no contacts in the magneto; thus no trouble can arise from dirt, &c., getting between and destroying the connection.

For further information on magneto generators and bells the reader is referred to the writer's work on telephones entitled 'Telephones; their Construction and Fitting.'

Relays.

Relays will be necessary on long circuits, where, from the resistance of the line, the current has not strength enough to ring the bell, but quite sufficient to attract the delicately poised armature of a relay. Many forms of indicators are also greatly improved by the addition of a relay, and when greater certainty of action is desired in an indicator a relay should always be fixed, to insure its effective working. The duty of a relay is to close a local circuit when actuated by a current circulating through its coils.

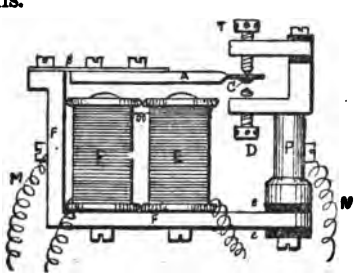

FIG. 84.—RELAY.

A form of the single-current relay is shown in Fig. 84. When a current circulates in the coils of the electro-magnet E E, the armature A is attracted, and the platinum contact C

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is pressed against the screw D. This closes the local circuit; the current flowing from wire M to frame F, armature A, contact C, screw E, to post P (insulated from the frame by the ebonite washers *e e*), leaving by wire N. The arm carrying the stop-screw T is also insulated from the post P by ebonite washers. In adjusting a relay, first screw up the screw D, so that when the contact C is pressing against the point there

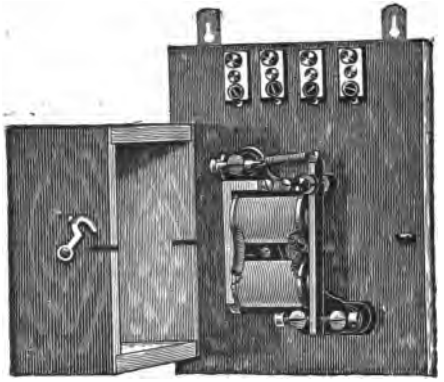

FIG. 85.—RELAY IN CASE.

is just room to pass a piece of paper between the poles and armature. Then adjust the stop-screw T, so that the contact C only fairly leaves the screw D. The tension of the spring S should only be such as will just bring the armature back against the stop-screw T.

Fig. 85 shows a relay complete in case.

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CHAPTER IV

INDICATORS.

WHERE there are many rooms and all are desired to ring on the same bell, an indicator must be provided so that the signalling from one room can be distinguished from that of another. In some instances, however, where there are only three or four rooms, it is often preferable to employ a different toned bell for each room; thus the servant can attend immediately to the summons without having first to go and look at the indicator. Indicator movements take a great variety of forms, but they may be divided into two distinct kinds, viz. those that drop a shutter or move a disc and require to be reset each time the bell is rung, and those that require no resetting, depending for their action on a pendulum which, when once started, swings for a considerable time. This latter form are called pendulum or self-replacing indicators, and are the form most extensively used. The first kind is capable of being again divided into two classes: (1) those in which the replacement or throwing back of the vane is effected by mechanical means; and (2) those in which, by pressing a button, a current of electricity from the battery is made to effect the replacement. The former are known as mechanical, and the latter as electrical "throwbacks." Of the two, for general purposes the pendulum indicators are much to be preferred, as an extensive use of the former has proved that servants cannot be implicitly relied on to replace the shutter. Thus when the

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bell rings there are perhaps some half-dozen shutters down, and great annoyance is caused by the servant not directly answering the summons. For this reason, and because from their simplicity they are more certain in their action, the pendulum indicators find the most favour. Fig. 86 shows the form of mechanical throwback movement now almost exclusively used. Originally designed on the Continent, it passed through several forms until it reached that shown, from which it has not altered for the last five years, notwithstanding the large numbers that have been manufactured. Its great point is its certainty of action, which places it a long way in advance of any movements of its kind.

FIG. 86.—MECHANICAL THROWBACK MOVEMENT.

Referring to Fig. 86, it consists, it will be seen, of two magnet cores, only one of which is wound. Above the magnet is pivoted a horizontal arm, one end of which carries the armature, while on the other end are cut two teeth that retain the vane in position. When the armature is attracted these teeth release the vane, which, being pivoted as shown in the figure, falls over, indicating the number of the room from which the signal has been sent. The vane is replaced by the pin on the rod of the throwback gear engaging with the bottom part of the arm carrying the vane and throwing it back. Another form of the mechanical throwback indicator is shown in Figs. 87 and 88, which consists of an electro-magnet E, provided with an armature A, pivoted at Y, and to which is fixed a light cardboard vane V. When a current flows round the electro-

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magnet, the armature is attracted by the poles P P, and the vane is moved up into the position shown in Fig. 87, and by the dotted lines in Fig. 88. The indicator is reset by pulling a cord, which causes a light metal rod to throw back the vane into its former position.

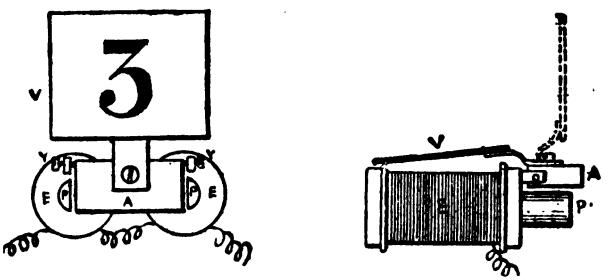

FIG. 87, 88.—MECHANICAL THROWBACK INDICATOR.

A mechanical throwback of American design, and one which can very readily be constructed, is shown in Figs. 89 and 90, Fig. 90 being a side-view of Fig. 89. To the frame *b* is fixed the electro-magnet *a*, opposite the pole of which is the armature *c*, pivoted at *d*. Into the top of the armature, which is bent over at right angles to the bottom part, is fitted the screw *f*, this screw regulating the distance of the armature from the pole of the electro-magnet. To the bottom of the frame *b* is pivoted at *e* the vane *m*, which, in its normal position, is supported by the armature catch *n*. By the weight of the top part of the armature the lower part is kept off the pole of the electro-magnet; but on a current passing through its coils the armature is attracted, and the vane, slipping off the catch *n*, falls into the position in which it is shown in Fig. 89, and by the dotted lines in Fig. 90. It will be seen from this that there are no springs required for either the armature or vane, the movement of both being controlled by gravity alone.

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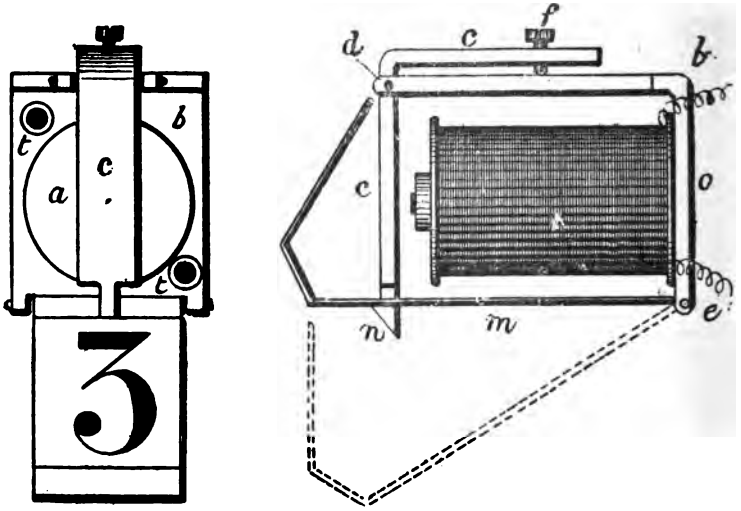
A neat little form of mechanical throwback movement is shown in Fig. 91. The magnet has one coil only, and soft iron extensions are made at each end so as to bring the poles at the side. Above the poles is pivoted the armature, in the centre of which is fixed a projecting tooth that engages with two notches on the spindle of the vane. When the armature



FIGS. 89, 90.—MECHANICAL THROWBACK MOVEMENT.

is attracted by the poles the tooth is withdrawn from the first notch, and after the vane has fallen, engages with the second one. By lifting up the vane the tooth is reset into the first notch.

For use on board ship a special form of indicator movement is necessary, otherwise trouble is likely to arise from vanes dropping down owing to the rolling of the ship, &c. A form of movement specially designed for ship work is shown in

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Fig. 92. In this form of movement the releasing gear to the vane is so arranged that it is not possible to release the vane other than by moving down the armature to the magnet pole.

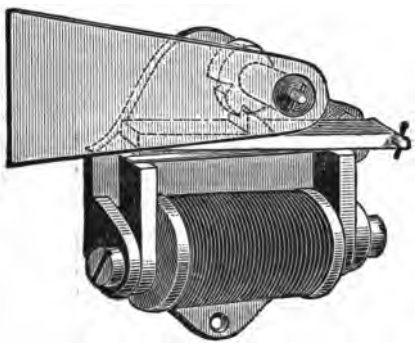

FIG. 91.—MECHANICAL THROWBACK MOVEMENT.

In addition to this the magnet winding is thoroughly soaked with paraffin wax, and all parts non-magnetisable made in brass so as to prevent the movement being corroded by the damp sea-air.

FIG. 92.—SHIP'S LOCKING MOVEMENT.

Fig. 93 is an internal view of a four-hole mechanical replacement indicator, showing the throwback gear and connections to the terminals; the throwback gear consists of the rod *a*, fitted with a knob at one end, and having four pins affixed to it at such points that when the rod is pushed along these pins will engage with the arms carrying the vanes and reset the vanes. The rod is kept in its normal position by the spiral spring *n*. The connections are shown

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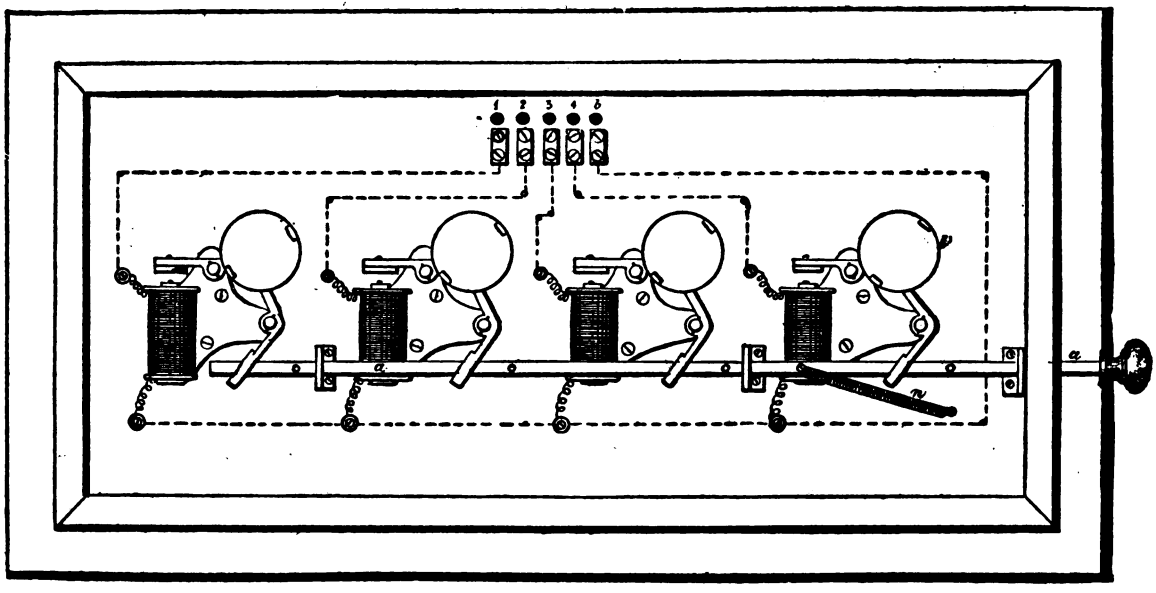

FIG. 33.—INTERNAL VIEW OF 4-HOLE MECHANICAL INDICATOR.

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by the dotted lines running to the five terminals 1, 2, 3, 4 and *b*. Terminals 1, 2, 3 and 4 are for the wires from the pushes, while *b* is connected to the bell.

Indicator cases are generally made either in polished walnut, mahogany or teak, the fronts being of glass, enamelled black, relieved by gold lines round the outside and also round the openings through which the vanes are visible. These openings are usually square, though they can just as easily be made circular, triangular or star-shaped. The terminals consist of brass connecting plates, and the wires connecting them to the movements consist of No. 24, silk covered, run on little pins. The wires from the pushes come in from the back of the indicator, passing through holes in the base just above the terminal plates.

The following are the usual outside dimensions of the different size indicator cases :—

No. of Holes.		Inches.		Inches.
3	.. ..	12	by	8½
4	.. ..	15	„	8½
6	.. ..	20	„	8½
8	.. ..	15	„	12
10	.. ..	18	„	12
12	.. ..	20	„	12
20	.. ..	24	„	18
30	.. ..	30	„	20

Electrical Replacement Indicators.

Electrical replacement indicators should only be used in places where it is absolutely necessary that the replacing of the vanes should be performed from a distance. These movements offer no advantages over the mechanical replacement, and the best of forms are somewhat uncertain in their action. Fig. 94 shows a form of the electrical replacement indicator, which consists of an upright arm A, pivoted at P, one end of

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which carries the vane D, and to the other is fixed the permanent magnet M, with its north and south poles N and S, projecting downwards. An electro-magnet E, wound with two coils, is fixed to the framework in such a manner that the pole T comes between the poles of the permanent magnet N. On a current flowing round the electro-magnet, the core becomes magnetised, the pole T exhibiting, let us say, north polarity. Then, since like magnetic poles repel and unlike attract, the pole T repels the pole N and attracts the pole S of the permanent magnet, throwing it over into the position shown by the dotted lines. The disc is moved back into its normal position by pressing a push, so connected that it sends a current in the reverse direction round the electro-magnet. The little arm H, which is fastened to A, can be moved into any position, so as to allow of the balance being restored should the indicator get out of adjustment.

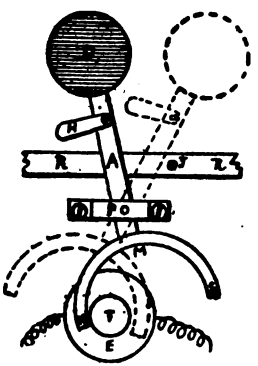

FIG. 94.—ELECTRICAL REPLACEMENT MOVEMENT.

Pendulum Indicators.

Two favourite forms of the pendulum indicator movement are shown in Figs. 95 and 96. These consist of an electro-magnet wound with No. 26 silk covered wire, fixed at one end to a metal frame and having at the other end an armature poised on a knife edge. From the bottom of the armature is suspended a light paper vane, and the armature when once set swinging by the attraction of the magnet continues to swing for 60 or 80 seconds before returning to its position of rest.

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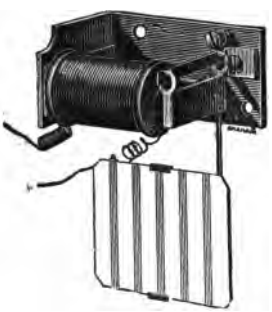
There is thus, it will be seen, no attention required on the part of the servant to replace the movements, as it is done automatically. Fig. 97 shows another form of the pendulum indicator, consisting of an electro-magnet E, provided with an armature A, one end of which is fastened to a spring S, supported by the post P, and the other carries a vane of corrugated silver glass, which, besides being visible in dark situations where a coloured vane would be useless, has the



FIGS. 95, 96.—PENDULUM MOVEMENTS.

advantage that the slightest movement can be readily detected even from a distance. On a current flowing round the electro-magnet, the armature is attracted and held against the poles so long as the circuit is closed; but on the circuit being broken the armature is released and swings backwards and forwards for about 80 seconds, finally returning to its normal position, as shown in the figure. Another form of the pendulum indicator is shown in Fig. 98, which works on the same principle as the preceding one. This form of indicator is not contained in a case like those previously described, but is generally fixed on an ordinary board placed in some conspicuous place. A relay is frequently employed in conjunction

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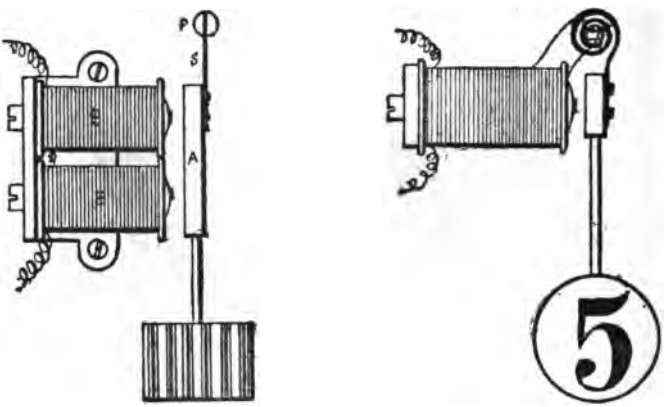
with the pendulum indicators, as the continual make and break of the circuit by the bell sometimes interferes with their satisfactory working.

Fig. 99 shows a case, with cover removed, of six pendulum indicators of the form described in Fig. 97, the connection to the terminals being shown by the dotted lines. As will be



FIGS. 97, 98.—PENDULUM INDICATORS.

seen from the figure, a relay R, which closes the bell circuit when its armature is attracted, is fixed in the right-hand side of the case. If no relay is used the connections of the indicator will of course be the same as shown for the mechanical indicator in Fig. 94.

Fig. 100 shows the appearance of a 6-hole mechanical indicator complete, there being two replacement buttons, one for each row of movements.

In some cases it is preferable to have the bell which is to work with the indicator fixed on the same base, as shown in Fig. 101, which shows a 3-hole pendulum indicator with shield

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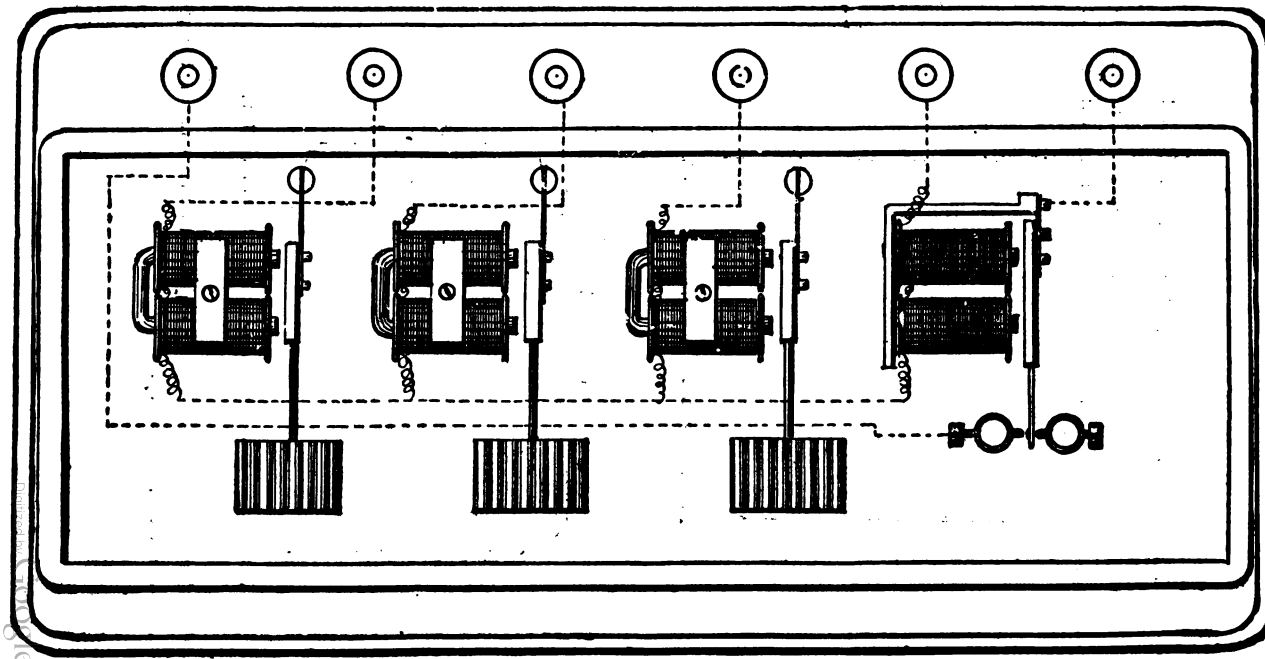

FIG. 99.—PENDULUM INDICATOR WITH RELAY.

bell attached. The connections to the bell are all run at the back of the base, so that the wire from the terminal inside the

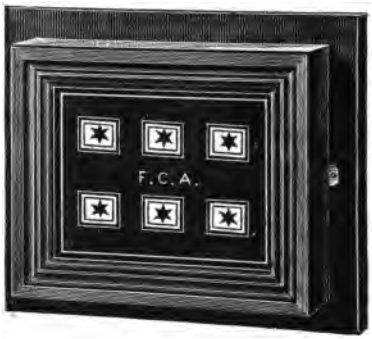

FIG. 100.—6-HOLE PENDULUM INDICATOR.

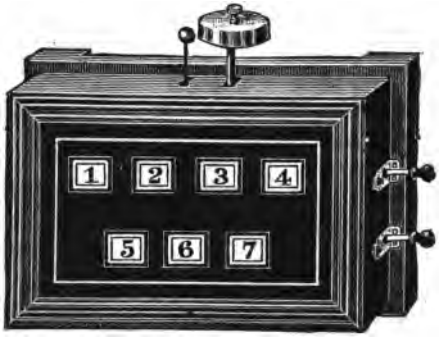

FIG. 101.—7-HOLE MECHANICAL INDICATOR WITH BELL.

case that would in the ordinary way be taken to the bell can be run direct to the battery.

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Indicators for Prisons and Asylums.

A form of indicator very useful for prisons, &c., on account of its great solidity and the impossibility of its being tampered with, is shown in Fig. 102. It consists of a cast-iron push cemented into the cell wall, the button *a* of the push being prolonged by the rod *b* to the contact portion *h*, which is similar in construction to the bell-pull described on page 27. In the space *i*, in front of the contact *h*, is pivoted the vane *c*, on the pivot *d*, and working through a slot in the corridor wall. When the button *a* is pressed, it causes the rod *b* to join the two contact springs at *h*, thus closing the circuit, while at the same time the end of the rod engages with the vane *c*, throwing it over into the position shown in the figure. In this position it arrests the attention of the warder as he comes along the corridor, who, after having attended the wants of the prisoner, throws back the vane *c*.

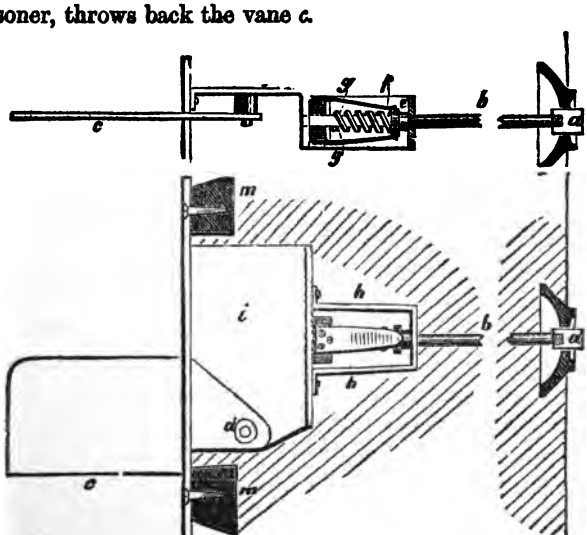

FIG. 102.—INDICATOR FOR PRISONS.

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CHAPTER V.

BURGLAR AND FIRE ALARM CONTACTS.

BESIDES the method of closing the circuit by pushes, pulls, &c., there are various other means by which the circuit is closed for the purpose of attracting attention or giving an alarm. These are, first, burglar alarm contacts, under which head come all contacts for fitting to doors, windows, safes, tills, &c., in such a manner that any movement of the door or window from its normal position will give an alarm by ringing a bell fixed in any convenient place. Second, fire alarm contacts, by means of which an alarm is given, either when a pre-arranged temperature has been reached, or by using a different form when any deviation is made from a certain temperature. Besides these, there are miscellaneous alarm contacts, such as for giving warning when the water in a tank has reached a certain level.

The police of an American city recently gave it as their opinion that the great decrease in the number of burglaries that had taken place in that city was due almost entirely to the extensive manner in which the householders had adopted burglar alarms, and there is no doubt that a properly fitted up system of electrical burglar alarms is the most efficient means of protecting a house. The chief point to be looked to in a burglar alarm is certainty of action in the contacts; and, as the apparatus must stand perhaps for months and months together without being called into action, the form of contact used must be of such design that it will stand for a long time

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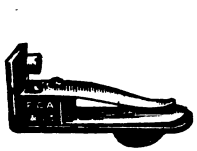
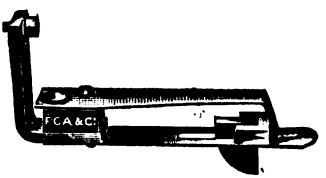
without any deteriorating surfaces. For this reason a rubbing action in the contacts is much to be preferred to a dotting one.

A form of shop door contact much used is shown in Fig. 103. It consists of a metal frame carrying two contact springs, the top one of which is fixed on a block of ebonite, thus insulating it from the frame. The bottom spring has attached





FIGS. 103, 104.—SHOP DOOR CONTACTS.

to it a semicircular ebonite stud so arranged that, when the contact is on the framework above the door, as the door opens and shuts so it causes the bottom spring to rise up and make contact with the top one, thus closing the contact.

A more convenient form of shop door contact is shown in Fig. 104, which *only* acts when the door is opened, thus reducing by half the number of rings and saving false alarms. It consists, as will be seen from the figure, of two springs, the one fixed on to, and the other insulated from, a metal frame of the form employed for the previously described contact. To the bottom spring is pivoted a brass hanger of the form shown, and so arranged that it can swing one way only. Thus, when the door is opened, the hanger, being unable to swing outward, causes the bottom spring, in order to ride over the door, to touch the top one and so close the circuit. As the door is shut again the hanger swings inwards, and thus the bottom spring remains stationary. Both this and the previously described form of contact have, it will be seen, a good rubbing action, tending to keep the contact surfaces clean.

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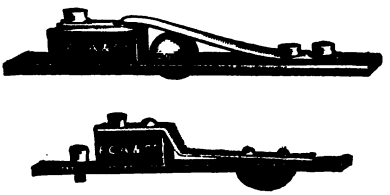
Two forms of burglar alarm contacts, intended for fitting to windows or the jambs of doors, are shown in Figs. 105 and 106. The form shown in Fig. 105 consists of a brass frame, at one end of which is attached an ebonite block, having fixed to it a German silver spring that in its normal position makes contact with the frame. Affixed to the end of the spring is a semi-circular piece of ebonite which, so long as the window or door



FIGS. 105, 106.—DOOR OR WINDOW CONTACTS.

is shut, keeps the end of the spring raised off the metal frame, and the circuit is thus broken. Directly the door or window is opened, if only for two inches, the spring is released, and, making contact with the brass frame, causes the bell to give an alarm. The form shown in Fig. 106 is similar, except that it has a metal ball instead of the ebonite stud. In both forms one wire is connected to the metal frame and the other to the contact spring. In fitting the contacts, the wood framing of the window must be cut away so that the metal frame of the contact is let in flush, leaving only the stud or ball of the contact visible.

Another form of window contact is shown in Fig. 107. Like the previous forms, the back part of the contact is let bodily into the window frame till the brass plate *b* is flush with the surface of the woodwork. When the window is shut right down, a counter plate fixed on the bottom of it engages with the rod *r*, pushing it down against the pressure of the

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spiral spring *s*. This causes the platinum pointed arm *a* to break contact with the brass plate *d*, which is insulated from the framework by the vulcanised fibre block *g*. If the window is now raised slightly the rod is released, and the circuit closed by the arm *a* moving up to the plate *d*, in which position it is shown in the figure. T T are the two terminals, the one being fixed to the frame and the other to the insulated brass plate *d*.

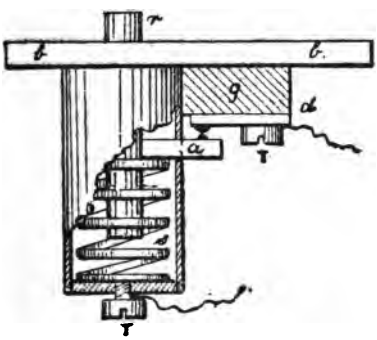

FIG. 107.—DOOR OR WINDOW CONTACT.

FIG. 108.—WATERTIGHT CONTACT.

A similar form of contact, only arranged so as to be as nearly watertight as it is possible to make a contact, is shown in Fig. 108. The contacts are all inside the barrel, and the two wires are connected on as shown. This and the preceding form are sometimes called barrel contacts, owing to their having a brass barrel to contain the contact points.

It is very often desired to be able to summon the servant at meal-times without having to get up from the table and go across the room to the push. For this purpose a contact is usually let into the floor within reach of the carver's foot. Fig. 109 shows the form of contact usually used for the purpose, consisting of a circular brass plate having attached to it a block of ebonite, on either side of which is a contact

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spring. Through the centre of this plate and ebonite block passes a brass contact rod, which, when depressed by the pressure of the foot on the plate attached, makes contact between the two springs, thus closing the circuit. When the weight of the foot is removed, the rod is returned to its normal position clear of the contact springs by a spiral spring.

FIG. 109.—FLOOR CONTACT.

Fire alarm contacts are used either for giving an alarm in case of fire, or indicating the fall or rise of temperature in hot-houses, &c. A large variety of forms have been from time to time devised, some acting by the expansion of air in a closed chamber, and others by the expansion of liquid. None of them, however, have been subjected to a long test, such as is necessary before much confidence can be placed in them. The great drawback to the majority of contacts is their uncertainty of action. They have, perhaps, been standing a long while, during which time dust and moisture have collected on the contacts, and when a fire does break out they fail to perform their duty. A system of unreliable fire alarms is, like a badly designed burglar alarm, worse than if the building had not been fitted at all, as the owner, placing confidence in his alarms, is apt to relax certain precautions which, were he without them, he would not think of overlooking.

The thermometer alarm is one of the most reliable, a form of this alarm being shown in Fig. 110. It consists of an ordinary mercury thermometer, into the bulb of which one end of the wire *d* has been fused, the other being connected to the terminal T. The other terminal T′ is connected to the platinum rod *r*, which passes through an india-rubber stopper into the upper end of the tube. Any rise in the temperature beyond a predetermined point causes the mercury rising in the tube to

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touch the end of the platinum rod *r*, thus closing the circuit and ringing the alarm bell. The rod *r* can, by moving the milled

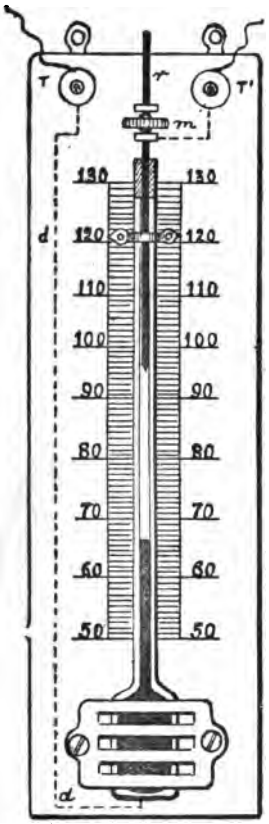

FIG. 110.—THERMOMETER ALARM.

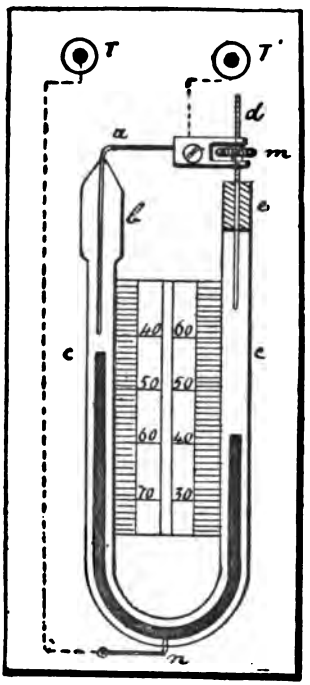

FIG. 111.—DIFFERENTIAL ALARM.

adjusting screw *m*, be set for any desired temperature. Differential thermometers fitted in a similar manner are sometimes used in hothouses to give warning to the attendant of any

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departure, either above or below, from the proper temperature. Fig. 111 shows a form of this thermometer. For the minimum contact a platinum wire *a* is fused into the bulb *b* of the tube *c*, at the required temperature. Another platinum wire *d* passes through the india-rubber stopper *e* into the other end of the tube and forms the maximum contact; it being adjusted for any temperature by the milled screw *m*. A third wire *n* is fused into the glass tube at the bend, this wire being always in contact with the mercury. The bulb *b*, down to the top of the mercury, is filled with spirit. T T' are the terminals, the connections being shown by the dotted lines. Any rise of temperature above 65° will close the maximum, while any fall below 40° will close the minimum contact.

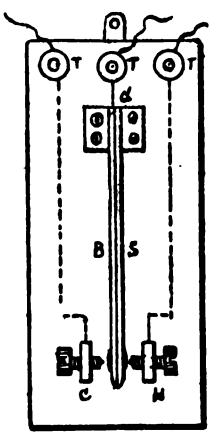

FIG. 112.—METALLIC ALARM.

FIG. 113.—FIRE ALARM.

A simple fire and frost alarm is shown in Fig. 110. A strip of brass B is riveted to a strip of steel S, the tongue thus formed being fixed at one end, *d*, and at the other free to move between the two contact screws C and H. Any rise of

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temperature moves the free end of the tongue towards H, and any fall towards C. This form, however, is not so reliable or sensitive as a good thermometer alarm.

For fitting in public buildings and other places where the alarms are likely to be tampered with and false alarms given, some such form of alarm contact as shown in Fig. 113 must be employed. In this form the spring plug that makes the contact is kept off the contact-points by the glass front of the alarm, the case of which is of cast iron. To give an alarm it is only necessary to break the glass, when the contact plug being released, shoots forward, closing the circuit and ringing the alarm bell. The majority of fire alarms fixed in the streets are worked on this principle, the alarm contact being fixed on an iron post, and the different posts being connected by underground wires with the nearest fire station.

Water-level Contacts and Indicators.

Some means of indicating when a tank or reservoir situated at some distance is full or empty is a great desideratum in water-works, and several forms of electrical contacts for this purpose have been designed.

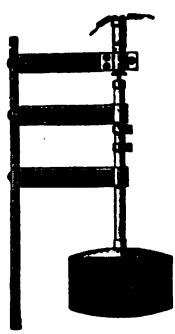

FIG. 114.—"FULL" CONTACT.

Fig. 114 shows a form of contact for indicating when a cistern or reservoir is full, or what is sometimes called a maximum contact. It consists of a copper float attached to an upright spindle that works in two guides.

Fixed on a separate arm above the top of the spindle is a contact enclosed within a metal barrel, the plunger of the contact projecting downwards to the top of the float spindle. So long as the cistern is empty and the water does not touch

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the float the top of the spindle does not touch the plunger of the contact and the circuit is open, but on the water reaching

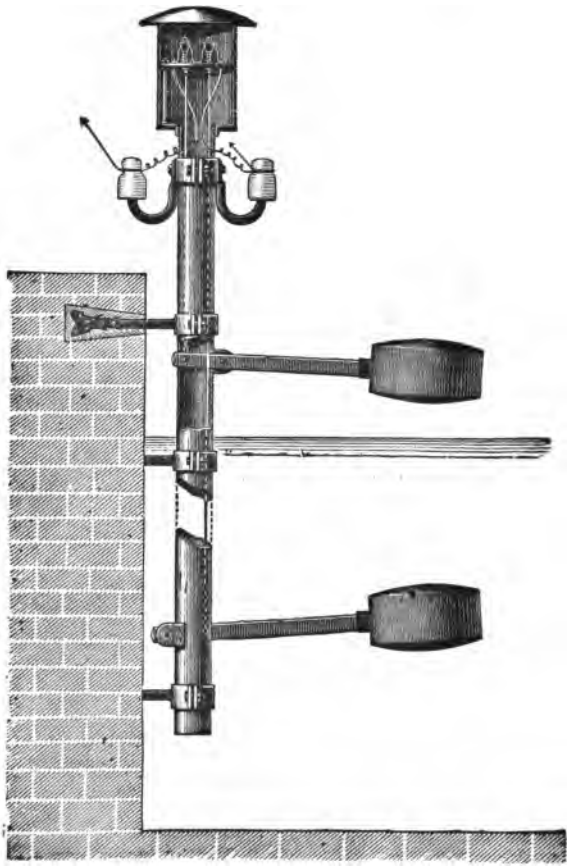

FIG. 115.—"FULL" AND "EMPTY" CONTACT.

the float, it rises and the top of the spindle engaging with the plunger of the contact, as shown in the figure, forces it up

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closing the circuit and ringing the alarm bell, which, with the battery, might be placed 1500 or 1600 yards away.

Another form of water-level contact, arranged to operate at both the maximum and minimum heights of water, is shown in Fig. 115. It consists of two floats pivoted on an arm as shown, each of which floats operates by means of a small chain to contacts placed in the enlarged portion of the tube at the top. Both floats, so long as they are submerged in the water, keep the contacts off and the circuit of each contact open, but directly the water falls, so each float as it is left dry, falls and closes the circuit to which it corresponds. There is thus an indication given both when the cistern or reservoir is empty and full. Two wires are of course required, which are fixed to the insulators shown, the return for each circuit being by "earth." Two bells of different tones, or else one bell and a two-hole indicator, are fixed at the pumping station for the purpose of indicating whether the reservoir is full or empty.

Another method of indicating the water level of a cistern or tank is shown in Figs. 116 and 117. Fig. 116 is the transmitting and Fig. 117 the recording apparatus. The transmitting apparatus consists of a grooved pulley attached to the spindle S, over which pulley passes a chain (not shown in the figure) attached to a float in the cistern. As this float rises or falls so the chain turns the pulley either in one direction or the other. By means of toothed wheels the spindle S drives another spindle just above it, to which are attached the segments A and A', fixed at an angle of 180° with each other. As this spindle rotates the cam A engages with the pin *b* on the hooked lever *b d*, causing this lever to move to the left against the pressure of the spring *f*, and directly the cam A has passed, the lever *b d* falls by its own weight, retarded somewhat by the action of the cam, making a momentary contact as it falls between the contact point *d* and the spring *c*. The battery

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connections are made to *b* and to *c*, so that a momentary current is sent to the recording apparatus. The reason that the lever *b d* is moved to the left on rising is so as to avoid making contact with *c* on the upward movement. When the

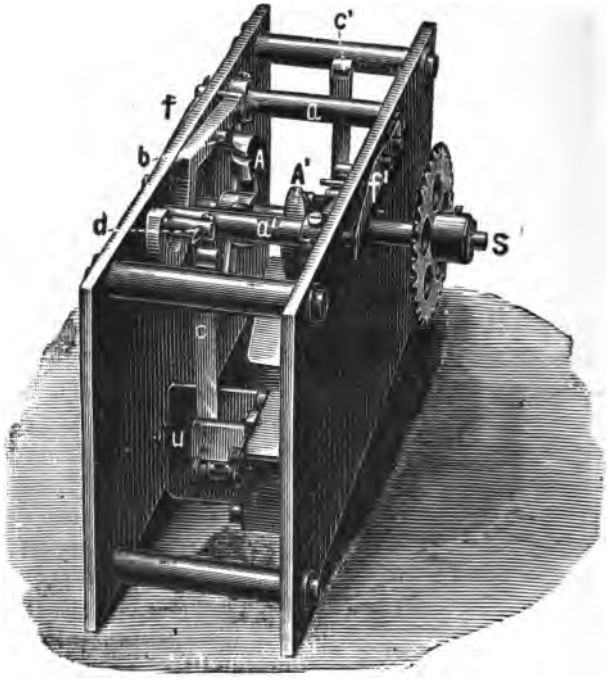

FIG. 116.—TRANSMITTING CONTACT.

pulley rotates in the opposite direction a similar action takes place with the cam A', lever *b' d*, spring *f'* and contact spring *c'*, sending a momentary reverse current to the recording apparatus.

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As the float rises, then, a contact is made each time the cam A passes the pin *b*, and as the float falls a contact is made each time the cam A′ passes the pin *b*′, the effect of this being to send a number of momentary currents (positive or negative,

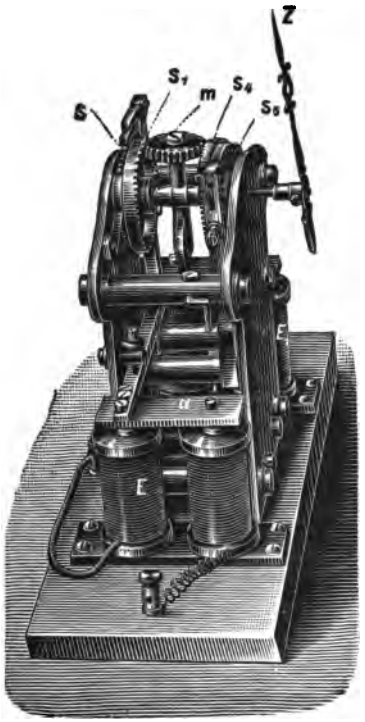

FIG. 117.—RECORDING APPARATUS.

according to the direction in which the pulley is moving) to the recording apparatus.

These currents, when they arrive at the recording end, pass through two polarised relays (see Fig. 179) the positive

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currents taking effect on the one relay and the negative on the other.

These relays are connected to the recording apparatus (Fig. 117), so that the one relay sends the current of a local battery through the pair of magnets E, and the other relay through the magnets E′. These magnets in the recording apparatus operate, by means of their armatures and cog gearing, the index hand Z, which moves in front of a graduated dial. The one pair of magnets rotates the index hand in one direction and the other pair in the opposite direction, and thus any variation in the height of the water in the cistern or reservoir is at once recorded on the dial by the index hand Z.

The connections for this and the previous water level contacts are shown on page 146.

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CHAPTER VI.

BATTERIES.

THERE are five different forms of batteries that may be employed for electric bell work:—1st, the Leclanché; 2nd, the Fuller bichromate; 3rd, the Daniell; 4th, dry batteries; and 5th, the Edison-Lalande.

It is very important that the battery employed should be a thoroughly reliable one and set up in a proper manner, as a failure of the battery causes a breakdown in the communication throughout the entire building, whilst the failure of a push or wire only affects that portion of the building in which the push or wire is fixed. A common fault is that of putting in (with a view to economy) only just enough cells as (when first set up) will do the necessary work. This is false economy, as when the cells are but slightly exhausted the battery power becomes insufficient; whereas, if another cell or two had been added, the battery would have run a much longer time without renewal, owing to the fact that each cell could have been reduced to a lower state of exhaustion, yet still the battery would have furnished the necessary power; and the author has always found that the extra expense of the surplus cells is fully repaid by the increased length of time the battery runs without renewal.

The Leclanché Battery.

A severe and prolonged test, extending over many years, has proved that for general electric bell work the Leclanché battery

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has no equal, though in large hotels, &c., where the work is likely to be very heavy, it may sometimes be preferable to employ a form of the Fuller bichromate or an Edison-Lalande cell.

The Leclanché cell (Fig. 118) consists, in its most usual form, of a glass jar, in which is contained the amalgamated

FIG. 118.—POROUS POT LECLANCHÉ CELL.

zinc rod, forming the positive element. The negative element (which is also shown in section in Fig. 119) consists of a carbon plate *c* placed inside the porous pot *p*, and surrounded with a tightly packed mixture of carbon and peroxide of manganese, the top of the porous pot being run in with melted pitch. In some forms of cells a corrugated carbon plate is used. The zinc rod or positive element is shown separately in Fig. 120. The Leclanché is a single-fluid cell, the porous pot serving

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not to keep two fluids separate, but merely to contain the broken carbon and manganese, and keep it in intimate contact with the carbon plate. The exciting fluid is a solution of salammoniac.

This solution has no chemical effect either on the zinc (provided it is pure) or the carbon and manganese, so long as the circuit is broken and the cell not at work. But on the circuit

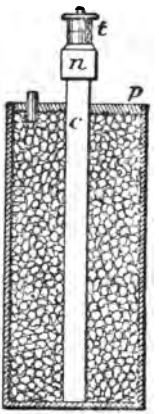

FIG. 119.—SECTION OF POROUS POT.

FIG. 120.—ZINC ROD.

being closed a current flows from the positive pole to the negative, and the action in the cell is as follows:—The solution of chloride of ammonia (salammoniac) is decomposed; the chlorine, attacking the zinc, forms chloride of zinc, which is soluble in the surrounding liquid; while the ammonia, developing at the surface of the carbon, forms a soluble compound with the oxygen which it extracts from the manganese. While the cell is at work, then, the zinc is consumed, and chloride of zinc accumulates in the solution, the carbon remaining

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unaltered, and the peroxide of manganese loses some of its oxygen. After a time, however, the supply of oxygen gets reduced, and hydrogen accumulates on the surface of the carbon plate, producing polarisation. But if the circuit is now broken, and the cell left to rest for a time, it will depolarise; the peroxide of manganese absorbing oxygen from the air.

The terminal *t* is fixed to the carbon plate (in a manner that will be readily understood by referring to Fig. 119) by means of the lead cap *n*. Simple as this battery seems, it is one of the most difficult to manufacture, and great care is necessary in fixing the lead cap, as if improperly done, the salts creeping up will eat away the connection.

Before the cap is fastened on, the top end of the plate is soaked in melted paraffin wax to prevent the creeping of the salts, after which two ¼-inch holes are drilled through the plate and the cap cast on, the lead which runs into these holes serving as rivets. Latterly some manufacturers are employing carbon caps and fastening the terminal with a nut, as shown in Fig. 124.

Another form of the Leclanché cell, known as the "agglomerate block" form, is shown in Fig. 121. In this form of cell a porous pot is not used, the depolarising mixture being applied to both sides of the carbon plate in the form of a block. The materials used in the construction of these blocks, which are similar to those contained in the porous pot, with the addition of from 5 to 10 per cent. of some cementing compound such as resin, are during manufacture submitted to a pressure of many tons.

In fitting up a cell of this form an agglomerate plate *a* (Fig. 122) is placed each side of the carbon plate C, and the two india-rubber bands *b b* slipped over them. These bands have at *d* a solid part, through which a hole has been stamped to receive the zinc rod. The zinc is thus kept from touching the

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negative element, and both elements can (by lifting at the positive terminal) be taken bodily out of the glass jar.

When these cells were first brought out great things were expected of them, and the following were the chief advantages claimed for them over the porous pot form :—

That a much better use was made of the depolarising power of the manganese, as its reduction was more complete; that,

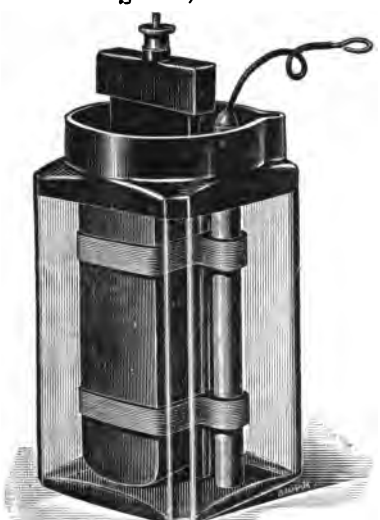

FIG. 121.—AGGLOMERATE BLOCK LECLANCHÉ CELL.

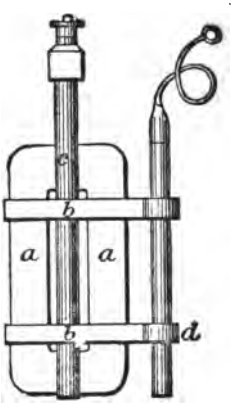

FIG. 122.—AGGLOMERATE BLOCK COMPLETE.

in consequence of the readier reduction of the manganese, the carbon plate was more rapidly depolarised, and consequently the E.M.F. was more sustained.

That its resistance was extremely constant, whatever the electro-chemical work done by the cell, and would, if anything, tend to diminish, owing to the formation of chloride of zinc, which is an excellent conductor.

That the battery was ready for use immediately on charging.

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as the liquid was brought at once into contact with the negative and positive elements.

That the renewal was exceedingly simple: when a cell is exhausted, the depolarising plates have only to be removed and fresh ones substituted.

A short trial of them, however, for practical work proved that they offered very little advantage over the preceding form. Their chief virtue is, of course, their low internal resistance

FIG. 123.—GLASS CELL.

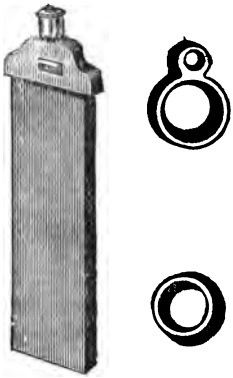

FIG. 124.—CARBON PLATE AND RUBBER BANDS FOR AGGLOMERATE CELL.

(owing to the non-use of the porous pot), though this is a doubtful advantage, except, perhaps, for bells arranged parallel. An injurious local action is also set up by impurities detached from the blocks settling on the rubber bands, and when this occurs to any great extent the consumption of zinc seems to go on just as much when the cell is at rest as when it is at work. This cell also polarises quicker than the porous pot-form, while it is exceedingly dirty to handle, and in the author's opinion is not equal to the old porous pot form, as shown in Fig. 118.

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A creeping of the salts up the inside and over the outside of the glass jar is a fault to which the Leclanché cell is very liable. This can, however, be entirely prevented by rubbing the neck of the jar with a little grease, or by dipping it for an inch or so in melted paraffin wax.

With a view also to prevent this creeping, the cells are sometimes sealed, i.e. the top is filled in with pitch, a hole being left for charging. The use of sealed cells, however, is not economical, as when exhausted they cannot well be recharged.

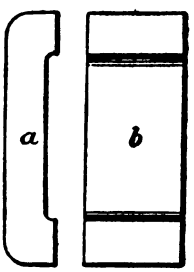

FIG. 125.—AGGLOMERATE BLOCK.

The position of the battery is a matter of some importance, as in warm or moist situations the creeping of the salts is greatly hastened. It should be placed on a shelf or in a cupboard near the bell. If this is not possible, the coolest place should be selected, keeping in mind, however, that it should be near its work.

A larger form of the Leclanché agglomerate block that is useful where a large current is required is shown in Fig. 126. It is known as the six-block agglomerate, and has a very low internal resistance. The negative element is shown in Fig. 127, and consists of a grooved carbon cylinder *a*, with the agglomerate rods *b b b* in each groove. The rods are kept in contact with the carbon cylinder by the wrapping of sackcloth *c*, outside which are two rubber bands.

The positive element is in the form of a zinc cylinder (such as is used in the Bunsen cell), which completely surrounds the negative element, the sackcloth preventing its coming into contact. The containing jar is of glazed stoneware. For bells in parallel, or where a large current is required, this form of cell is very useful, as, owing to its construction, it has a very

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low resistance, its E.M.F. being 1·55, and its resistance ·20 of an ohm.

FIG. 126.—SIX-BLOCK AGGLOMERATE CELL.

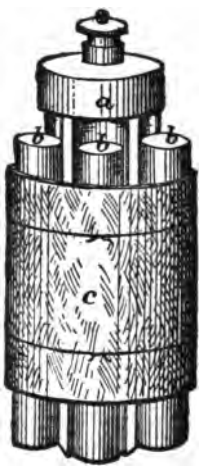

FIG. 127.—BLOCK COMPLETE.

The Lacombe-Leclanché Cell.

A modification of the Leclanché cell that has lately been introduced is shown in Fig. 128. In this form of cell the carbon element, instead of being inside a porcelain tube, as in the ordinary form, consists of a carbon pot, the inside being packed with the depolarising mixture of peroxide of manganese and carbon. This carbon (see Fig. 129) is perforated with holes and has a well in the centre, and in this space is placed the zinc rod. The cell in actual practice has been found to give fair results, and has a low internal resistance.

The porous pot form and agglomerate block Leclanché cells are made in three sizes—Nos. 1 2 3—No. 1 being generally

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the smallest. Some manufacturers, however, number their cells in exactly the opposite manner, their No. 1 being the largest. It is a pity that some standard method of numbering is not adopted, as it often leads to great confusion when order-

FIG. 128.—THE LACOMBE CELL COMPLETE.

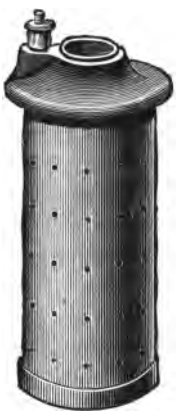

FIG 129.—CARBON ELEMENT OF LACOMBE CELL.

ing; though there is perhaps some consolation in the fact that No. 2 is always the same, and this is the size most generally used.

Setting-up Batteries.

In setting up a battery, fill up the outer jar three-quarters full with water, taking care not to splash the terminals; then put in as much salammoniac as will saturate the solution and leave a few crystals at the bottom.

The following are the quantities of salammoniac required to charge each cell:—For a No. 1 (small size), 2 oz.; for a No. 2 (medium size), 3 oz.; and for a No. 3 (large size), 5 oz.

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The battery (unless an agglomerate block) will not start at once. If the battery is required immediately, a little solution should be made in a jug and poured into the porous pot through the opening at the top, having first cleared out the air-hole with a piece of wire, or a small hole may be knocked in the bottom of the porous pot so that the liquid rises at once to the same level as that in the jar.

These batteries, when once set up, require little attention, and will run without recharging for a period varying between six months and two and a half years, according to the size of the battery and the amount of work it does. The battery should, however, be inspected at frequent intervals, especially in hotels, &c., where the sudden running down of a battery is a source of great annoyance.

When inspecting a Leclanché battery the following points should be looked to:—See that the salts are not creeping over the glass jar; if so, the faulty jar must be taken out, washed, well dried, and the neck rubbed with grease. See that the zincs are not eaten away, and scrape off any crystals that may have formed on them. Should the zincs be very black, while a strong smell of ammonia comes off from the porous pot, it indicates excessive working, probably a short circuit on some of the wires, which must be seen to. See that the solution has not evaporated; if so, fill up with water. If the solution is opaque or milky, add more crystals till it becomes clear again, or substitute a new solution. See that none of the solution has got on the terminals, or it will rapidly eat them away. See that no white lead is forming between the lead cap and carbon plate, as, owing to the bad conducting power of the white lead, increased resistance is thrown into the circuit.

When recharging a Leclanché battery it will be necessary first to see if the zincs are still good and not eaten all away. If the zincs are in fair condition, renew the solution, and should

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this effect no improvement, new porous pots or agglomerate plates must be substituted for the old ones. Owing to the slight cost of the new porous pots, it is never advisable to attempt to recharge the old ones, which, at the best, is a difficult and tedious operation.

The Fuller Battery.

The Fuller bichromate battery, as regards its use, may be looked upon as a sort of compromise between the Leclanché and the Daniell. The Leclanché should always be employed for intermittent work; the Daniell for closed circuit work, where a constant current for long periods is required; and the Fuller and Edison-Lalande bichromate in places where the work is too heavy for the Leclanché (there not being sufficient intervals of rest to allow it to recover itself), and yet the current is not required continuously so as to warrant the employment of a Daniell.

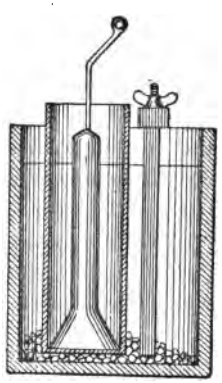

FIG. 130.—FULLER CELL.

In the "Fuller" cell (Fig. 130), for the negative element a carbon plate is employed, this plate standing in an outer glass or stoneware jar. Inside the jar is a porous pot containing a zinc rod, which forms the positive element. Water only is used in the porous pot, while in the outer jar is placed the following solution:—

Bichromate of potash	6 oz.
Water (hot)	2 pints.
Sulphuric acid	6 oz.

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The bichromate of potash should first be mixed with the water, and, when the solution is cool, the sulphuric acid added drop by drop, the mixture being constantly stirred with a glass rod.

A solution may also be made with chromic acid, by which the strength of the battery is much increased and its constancy improved. The following makes a good chromic acid solution :—

Chromic acid crystals	1 lb.
Water (cold)	1½ pints.
Sulphuric acid	7 oz.

As will be seen from the figure, the zinc rod is cast cone-shape at the bottom, as the base is most acted upon. Sometimes the coned part only is used, being cast on to a copper rod, but zincs of the shape shown are to be preferred, as the fluid acts on the copper rod unless well insulated. The zinc must be well amalgamated, and a couple of ounces of mercury placed in the bottom of the porous pot to keep up the amalgamation. To prevent too rapid a diffusion of the liquids, thickish porous pots should be used, the pots being paraffined all over except a band of about 2 inches at the bottom. Such a battery, if properly set up, will run for a period of from three to six months' duration (according to the amount of work it does) without attention, when the solution, and probably the zincs, will require to be renewed.

The Daniell Battery.

Neither of the two forms of batteries just described are any good for furnishing a current for long periods at a stretch, and when a battery is required to work continuously on closed circuit, a Daniell cell (preferably the gravity form) should be employed. For the "gravity" cell a glass jar, see Fig. 131, 12 inches high and 10 inches in diameter, should be employed, fitted with a porcelain or wood cover saturated with paraffin

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wax. An inverted funnel, made from 4-lb. sheet lead, stands in the centre of the jar, the bottom part of the funnel being perforated with numerous holes. A cast zinc ring, with two projecting lugs on the top, is slung from the lid of the jar, the lugs passing through two holes in the lid, and pins being slipped through to secure them. One of these lugs has a terminal fitted on the top, another terminal being also fastened to the lead funnel.

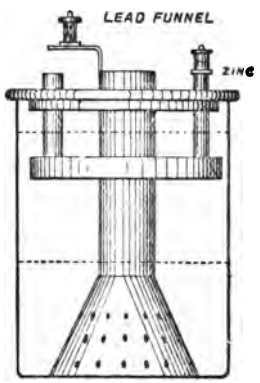

FIG. 131.—GRAVITY DANIELL CELL.

To charge the cell, water, to which has been added three or four drops of sulphuric acid, is poured into the glass jar. A saturated solution of sulphate of copper is next slowly introduced into the top of the lead funel; this solution, by virtue of gravitation, remaining at the bottom of the jar, and displacing the water upwards. Crystals of copper sulphate are then dropped into the lead funnel through the opening at the top, till the perforated part of the funnel is full.

Another method of charging the battery is as follows:—Drop copper sulphate down the neck of the funnel till it is full, and then pour in cold water till the level of the liquid is above the top of the zinc ring. The two terminals should then be joined with a piece of thick wire, so as to short-circuit the battery, the battery being kept short-circuited for about twelve hours. On inspection it will be found that copper has been deposited on the lead funnel from the sulphate, thus converting it into the copper or negative element of the battery. Care must be taken not to shake the battery when once set up.

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These cells will run on a closed circuit for periods of from three to five weeks without attention, and then all that they require is to have the funnel filled with copper sulphate, and some of the top liquid drawn off with a syringe and replaced with water. The zinc must also be scraped to clear off the copper that has been deposited thereon. The liquids have less tendency to diffuse if kept continually on closed circuit than when the cells are allowed intervals of rest.

Fig. 131 shows a form of the gravity cell.

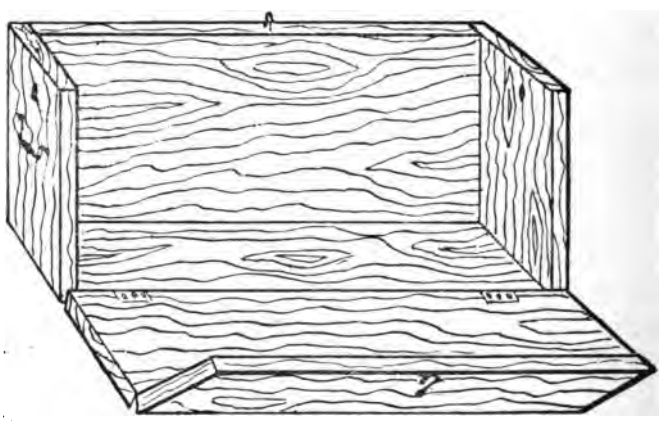

FIG. 132.—BATTERY BOX.

All batteries should be contained in a box, and Fig. 132 shows a convenient form for this purpose. The front and lid are so hinged that, when released, they fall over outwards into the position shown in the figure, thus allowing ready access for inspection.

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Dry Batteries.

These are chiefly intended for use in portable electric bell sets and similar cases, where a battery that is free from slopping and spilling of acids is a great desideratum.

On their first being introduced, they at once took the public fancy, and large quantities were bought and used for purposes for which they were never intended, with the inevitable result of failure and dissatisfaction.

The first inventors, Mr. Jensen and Mr. Carl Gassner, never suggested that dry batteries should be used instead of the Leclanché, but only for such purposes in which, from its containing liquids, the Leclanché is unsuitable.

For general electric bell work, heavy strain and long periods of use, dry batteries have proved perfectly useless, but for portable sets and similar cases, where one can put up with the bursting and occasional sudden running down to gain freedom from spilled solutions, the dry battery is excellent and has proved a great boon.

Of course it is now generally understood that all so-called dry batteries are in reality moist, and dry only in comparison with batteries in which liquids are freely used. The exciting composition is in the form of a paste or jelly, the viscidity of which varies with the temperature, and once the composition of this jelly became generally known, innumerable forms of dry batteries sprang into existence.

The negative and positive elements are the same as the Leclanché, and in fact, dry batteries are merely a modification of the Leclanché, with the exciting composition applied in the form of a paste.

Figs. 133 and 134 show two different makes of dry batteries, and Fig. 135, a section of Fig. 133, shows the internal arrangement. Referring to these figures, the negative element

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consists of a carbon plate, outside which is the positive element in the form of a zinc cylinder, the intervening space being filled in with the exciting paste. Connection is made to the zinc cylinder by means of a wire that is soldered to it, while

FIG. 133.

FIG. 134.

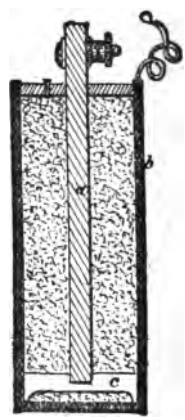

FIG. 135.—SECTION

a terminal is provided for making connection to the carbon plate. The outside of the zinc cylinder is pasted with an ornamental glazed paper to improve the appearance.

The E.M.F. of most dry cells is 1·55, while their internal resistance is somewhat lower than that of Leclanché cells of a similar size.

The battery, when exhausted, is recharged by sending a current of two or three ampères through it for a few hours.

As the outside zinc case forms one of the elements, care must be taken that the cells do not touch one another when

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connected up, or the cells will be short-circuited. To prevent this, it is as well to divide the battery-box into separate compartments, one for each cell.

It is also advisable, when the battery is intended to be placed in a damp situation, to wrap up each cell separately in two or three layers of paraffined brown paper. In warm places, where the Leclanché is often an intolerable nuisance, the dry cell works to perfection. The flat form is well adapted for use in portable electric bell sets. Fig. 136 shows a set of four dry cells in box, a very convenient arrangement when a small portable battery is required.

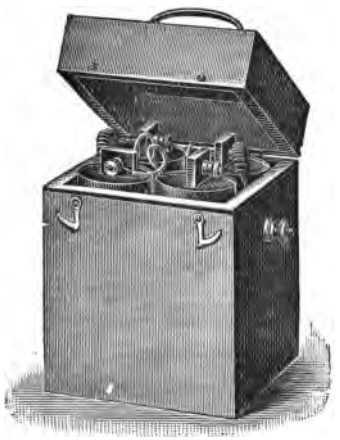

FIG. 136.—SET OF DRY CELLS IN BOX.

The Edison-Lalande Battery.

It is only quite recently that the Edison-Lalande battery has attracted much attention in this country. It is an improvement by the great inventor Thomas Alva Edison, on the Lalande-Chaperon battery, and has so many good points that, when better known and its action understood, it must come largely into use. Its most important points are :—

1. Great constancy.
2. Entire freedom from local action when on open circuit.
3. Low internal resistance.

The containing jar of the Edison-Lalande battery (see

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Fig. 137) is of glass, or else white glazed porcelain, and the elements employed are zinc as the positive, and black oxide of copper (CuO) as the negative. The exciting liquid is simply a solution of caustic potash. The oxide of copper is obtained by the process of roasting copper-scale, the oxide being afterwards ground into a fine powder and compressed into solid blocks. From these blocks, plates of a suitable size

FIG. 137.—EDISON-LALANDE CELL.

for the different cells are cut, which are then reduced on the surface to form a good conductor. These plates are suspended from the cover of the containing-jar by means of a light framework of copper, one end of this framework carrying the terminal for the positive pole of the battery. On each side of the copper element in the larger type of cells (but on one side only in the smaller types) is suspended a rolled zinc plate. These plates are suspended from the top of the porcelain

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cover by means of a brass bolt, one end of which carries the terminal, while the other is passed through a raised portion of the cover, to which they are thus firmly bolted. This prevents any movement in the relative position of the elements, and does away with the necessity of using separators to prevent any short circuits occurring between the elements in the solution. The zincs are amalgamated, and, as in most batteries, the zinc is attacked more vigorously near the top than at the lower part of the plate, the zincs for this cell are made slightly tapering, the thick part being uppermost.

The exciting liquid employed in the battery consists, in all types, of 25 per cent. solution of caustic potash in water; or, in other words, of a solution of one pound of caustic potash in three pounds of water. When the circuit is closed and the cell is put into action, the water is decomposed, and the oxygen forms with the zinc oxide of zinc, which in turn combines with the potash to form an exceedingly soluble double salt of zinc and potash that dissolves as rapidly as it is formed, while the hydrogen, liberated by the decomposition of the water, reduces the copper oxide to metallic copper. This reduced copper is of great purity, and can, moreover, if desired, be converted again into copper oxide. The potash is manufactured in sticks, varying in size according to the type of cell, and when the solution is exhausted a renewal is effected by simply placing a stick in the cell and pouring in the requisite quantity of water. A layer of heavy paraffin oil $\frac{3}{8}$ inch deep, is poured on top of the solution to exclude the air and prevent creeping. As for inspection and supervision, it suffices to say that, when once set up, the battery may be left, like the Leclanché, for months together without inspection and without trouble arising from creeping of the solution or noxious fumes.

There are three sizes of the Edison-Lalande battery com-

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monly employed, size No. 1 having a capacity of 600 ampère hours, the dimensions of the containing-jar being 7 × 15 inches. Size No. 2 has a capacity of 300 ampère hours, and the jar is 5½ × 13½ inches; while size No. 3 is of 150 ampère hours, and has a jar 5½ × 8½ inches.

To make Solution.—Place the requisite amount of potash in jar, and fill up with water to first line on inside. Stir the solution occasionally with a piece of wood until the potash is entirely dissolved. It will then be found necessary to add a little more water to bring the solution up to the first line again. Then pour a layer of heavy paraffin oil on the solution until it covers the second line.

To set up Cells.—Unscrew the nuts from the screws on the two side pieces of the copper frame, and pass the screws through the two round holes in the cover. Replace the flat jamb-nut on one of the screws, and one of the thumb-nuts on the other screw, and tighten both down until the frame sides are rigidly clamped to the cover.

Replace the other thumb-nut on the screw, holding jamb-nut. Slip the hard rubber insulating tubes over the sides of the frame (one on each side); then slide one of the oxide plates sufficiently far into the frame to enable one of the copper bolts to be passed underneath it, through the slots in the middle of the frame sides, and the copper nut tightened up on same. Afterwards slide the other oxide plate into the frame, and pass the remaining bolt through the slots at the bottom of frame sides, tightening up same with the nut belonging to it.

Pass the necks of the two zinc plates through the rectangular holes in the cover until the holes in the necks are in a line with the horizontal hole in the knob. Then pass the short brass bolt through the zincs and the knob and screw on jamb-nut, which should be firmly tightened up, so that the

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zinc plates are held perfectly rigid. The terminal can then be screwed on.

Be careful that the zinc plates do not touch the copper oxide plates, or the battery will be short circuited.

The copper connection is made between the terminal and the jamb-nut on one end of the copper frame, and the zinc connection between the terminal and the jamb-nut on the brass bolt suspending the zincs.

Soak elements in water to prevent the oil from adhering to them, and afterwards place cover on jar, with elements attached.

It is important that the oxide plates should be entirely submerged in the caustic potash solution, so that the top edges of same should be at least one inch below the layer of oil. Also it is of vital importance that the oil above referred to should not be omitted. When oil is not used, creeping salts are formed, and the life of the cell is reduced fully two-thirds.

When renewing cells, be careful to see that the binding posts at points of contact are perfectly clean and bright. They can be easily cleaned with a small piece of emery paper, and it is absolutely essential to the proper working of battery.

We will now turn our attention to a few of the different ways in which cells are connected up. Each outer jar, with its two elements and the liquids in which they are immersed, is known as a *cell*, and any number or combination of cells is called a *battery*. Much battery power is often wasted by want of knowing how the cells may be arranged to their best advantage, which depends entirely on the resistance of the circuits and the construction and arrangement of the apparatus that they are required to work.

When the two elements of a cell are brought into contact with their exciting liquid or liquids, an electrical disturbance is set up, and the positive element is raised to a higher

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potential than the negative. There is thus a difference of potential between the two elements which tends to produce a flow of electricity from the element of higher potential to that of the lower. This tendency to produce a flow is called *electro-motive force*, or for brevity sake E.M.F. If we connect the two terminals of the cell with a piece of copper wire, a current of electricity will flow through the wire from the negative to the positive element, and, inside the cell, through the liquid from the positive element to the negative. The terminal from which the electricity appears to start as it flows through the wire is called the *positive*, and that towards which it flows the *negative* terminal. It will be seen from this that the positive terminal is on the negative element, and the negative terminal is fixed to the positive element, and the fitter should not confuse the two, bearing in mind also that the current *always* flows (outside the cell) from the positive to the negative terminal. When the terminals of a battery are connected across by a piece of wire, the circuit is said to be *closed;* but when the wire is severed, the circuit is *open*. There are two things that impede the flow of electricity when the circuit is closed. These are: first, the resistance of the wires (as the best of conductors offer some resistance); and second, the internal resistance of the battery itself.

An analogy to the flow of electricity may to some extent be found in the flow of water in pipes. Thus, suppose a large cistern full of water is placed on the top of a building and connected by means of a pipe to an empty cistern at the bottom, a tap being inserted in the pipe for the purpose of controlling the flow of water; then the difference of level of the two cisterns will produce a pressure, which, when the tap is turned on, causes a flow of water. When the tap is turned off, the difference of level still produces a pressure down as far as the tap, but as there is no passage for the water, no flow

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can take place. So with the battery; so long as the circuit is closed a flow of electricity takes place, but when the circuit is opened the flow ceases, though there is still the tendency to produce a flow consequent upon the difference of potential between the two elements.

The E.M.F. of a cell, which varies in the different kinds, is determined by the nature of the elements and exciting liquids, and is quite independent of the size of the cell. Thus the E.M.F. of a Leclanché which is 1·60 volts, is just the same for a cell of one pint capacity as for one with a capacity of ten gallons. But, although increasing the size of a cell does not increase its E.M.F., any increase in the size of a cell is accompanied by a corresponding decrease in its resistance. For in a cell, which from the surface of its elements has an internal resistance of one ohm, doubling the surface of the plates will reduce its resistance to ½ ohm, and making them four times the size to ¼ ohm.

Ohm's law, so called from Professor G. S. Ohm, by whom it was first enunciated, determines the strength of the current in a circuit, it is—*that the strength of the current varies directly as the electro-motive force, and inversely as the resistance of the circuit.* From this we see that if we want to increase the current strength in our circuit we can do so in two ways, either by increasing the E.M.F. of our battery, or (provided the battery is of low resistance) by reducing the resistance of the circuit. The standard of electro-motive force is the *volt*, and one volt is roughly the E.M.F. of a Daniell's cell. The standard of current strength is the *ampère*, and that of resistance the *ohm*. From Ohm's law we get a formula relating to current, electro-motive force, and resistance, which is usually written as follows:—

$$\text{Current} = \frac{\text{Electro-motive force}}{\text{Resistance}},$$

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for which the initials of the words are generally substituted, for brevity sake, as shown below:

$$C = \frac{E}{R},$$

which means, that if we divide the resistance of the circuit in ohms, into the E.M.F. in volts at which the current is supplied, the quotient will be the current strength in ampères. Likewise, if we know the value of any two out of the three quantities, by an application of the formula, the third can at once be found; for it is obvious that the equation $C = \frac{E}{R}$ may be written $R = \frac{E}{C}$ or $E = C \times R$.

Thus, from Ohm's law, we see that to produce one ampère of current in a circuit having one ohm resistance requires an E.M.F. of one volt. If we increase the E.M.F. to two volts without altering the resistance of the circuit, we get two ampères, and if we still further increase the E.M.F. to four volts, we get four ampères of current. Similarly, if keeping the E.M.F. at one volt, as in the first instance, we reduce the resistance of the circuit to half ohm, we get a current of two ampères; and if we still further reduce the resistance to quarter ohm, we get four ampères. Going back to our analogy of the cistern and waterpipe, we will suppose the tap in the pipe to have been removed, and the water to be flowing as fast as the pipe will let it into the bottom cistern. Let us presume that the pipe is of such diameter that the water is passing a given point in the pipe at the rate of one pint per second; it is evident then, that if we wish to increase the flow of water to two pints per second, we can do so in two ways, either by increasing the pressure so as to force the water through at double the rate, or leaving the pressure the same, we can

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double the area of the pipe, which will produce the same result.

The following table shows the E.M.F. and internal resistance of the different cells just described :—

Name of Cell.	E.M.F. in Volts.	Resistance in Ohms.
Leclanché (Porous pot) No. 1	1·60	1·13
„ „ „ 2	1·60	1·10
„ „ „ 3	1·60	·9
„ (Agglomerate) „ 1	1·55	·70
„ „ „ 2	1·55	·60
„ „ „ 3	1·55	·50
Fuller, 1 quart	1·80	·50
Gravity, 2 quarts	1·07	9·0
Dry, 8 by 3¼ inches	1·55	·35
„ 6 by 2 inches	1·55	·80
Edison-Lalande, 7 by 15 inches	·75	·03
„ 5½ by 13½ inches	·75	·75
„ 5½ by 8½ inches	·75	·75

If we wish to know what current we shall get in any circuit, we proceed thus :—We first find the resistance of our circuit, which we will presume is found to be 4 ohms, including the resistance of the batteries themselves. From our table of E.M.F. and resistances of the different cells we can find the E.M.F. of our batteries, which in this case we will say is 6 volts. Now by the formula

$$C = \frac{E}{R}$$

we get, substituting the numerical values for the symbols,

$$C = \frac{6}{4}; \text{ therefore } C = 1\tfrac{1}{2} \text{ ampères.}$$

Again, if we know that our current flowing is 1½ ampères and the E.M.F. of our batteries 6 volts, what is the resistance of our circuit ?

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Now

$$R = \frac{E}{C} \qquad R = \frac{6}{1\frac{1}{2}} \qquad \therefore R = 4 \text{ ohms.}$$

which, allowing 2 ohms as the resistance of the cells, gives 2 ohms as the resistance of the external circuit.

Similarly, if we know the current and resistance, we can find the E.M.F.

Thus—

$$E = C \times R \qquad E = 1\tfrac{1}{2} \times 4 \qquad \therefore E = 6 \text{ volts.}$$

Now it is not the intention of the author to advise the fitter (after the wiring has been done and the bells and other appliances fixed) to sit down (as the electrical engineer might do when working out the size of the circuits) and go through a long mathematical calculation as to the best number and size of cells to employ, since this is wholly unnecessary; but rather that he should, by a glance at the length of his wires and an inspection of the winding of his bell coils, obtain a rough idea of the resistance of his circuits and the current he requires. If he knows the resistance the different size wires offer per yard, &c., he can easily (after reckoning up the amount of wire used) get a pretty accurate knowledge as to the resistance of his circuits. For this reason we subjoin the following approximate table, which shows the number of feet to the ohm, yards per lb., &c., of the different size copper wires.

Size of Wire, B.W.G.	Decimals of an Inch.	Yards per lb.	Ohms per lb.	Number of Feet to 1 Ohm.
No. 14	·083	15	·07	665
„ 16	·065	26	·19	405
„ 18	·049	45	·59	230
„ 20	·035	89	2·27	150
„ 22	·028	140	5·55	75
„ 24	·022	227	14·55	45
„ 26	·018	339	32·48	30

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If his circuits are long, and the coils of his bells and indicator movements wound with fine wire, he will know that he will require a small current with a fairly high E.M.F. When, as in this case, the object is to get a high E.M.F. with a small current, the cells must be joined in *series* as in Fig. 138, which shows three Leclanché cells in series. In joining cells in series, the carbon terminal of the first cell is left free, and the zinc of the first joined to the carbon of the second, and the zinc of the second to the carbon of the third; the zinc of the third

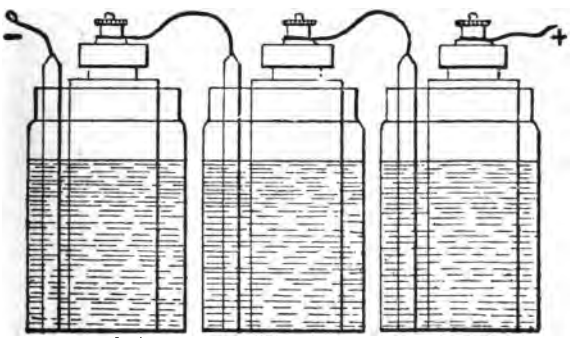

FIG. 138.—CELLS IN SERIES.

being left free. In the case mentioned above, three cells would hardly be sufficient, six No. 2 being more like the number that would be required. As we add cell after cell to the series, so we increase the total E.M.F. of the battery by that of the cell that is added. Thus, in Fig. 131, where we have three cells in series, the E.M.F. of the battery, instead of being that of a single cell, which is 1·60 volts, is 1·60 1·60 + 1·60 = 4·8 volts. It must be borne in mind, however, that in adding cells to the series we also increase the internal resistance of the battery as well as the E.M.F. Thus, in Fig. 138,

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the resistance of the battery is three times that of a single cell, being 2·70 ohms instead of 0·9.

The current required to ring a bell depends on the size of the bell and the winding of its coils. A small bell takes perhaps only ½ ampère, while the larger bells will take from 2 to 3 ampères. If the bells to be rung are wound with thick wire, or there are many bells in parallel, the resistance of the circuits will be low, and the battery must be of low resistance

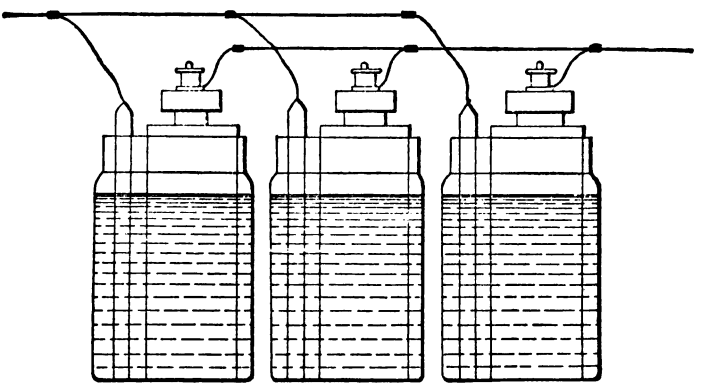

FIG. 139.—CELLS IN PARALLEL.

also. This can be done by joining up the cells in *parallel* as in Fig. 139, which shows three cells so joined up. The resistance of the battery is much reduced by joining the cells in parallel, the battery in Fig. 139 having only one-third the resistance of a single cell. Coupling up the cells in parallel amounts to increasing the size of the elements of a cell, and the E.M.F. of a battery so connected is only equa to the E.M.F. of a single cell. It is better, however, where possible, to use very large cells in series, in preference to coupling up a

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lot of small cells in parallel. It should be borne in mind that nothing is gained by stinting the battery power, and that another cell added to the battery will give more satisfaction than spending half an hour or so trying to get a delicate adjustment of the bell

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CHAPTER VII.

CONNECTING-UP.

THE following diagrams show the various ways of connecting-up bells, indicators, &c., and though the methods most usually required are shown, nearly every building may require some little modification of the arrangements here described.

Simple bell circuit.—Fig. 140 shows a simple circuit, consisting of push, battery, and bell. The cover of the push P has been removed, showing the connections to the contact springs, one of which, for the purpose of distinction, is shown darker than the other. The bell B (shown in detail in Figs. 55 and 62) has its cover on; thus none of the movement is visible. Z and C are the respective poles of the battery D. On the two springs of the push being pressed together the current flows from the positive pole C of the battery to the terminal L, through the bell to the terminal E, and thence by the wire and push-springs to the negative pole Z. Both in this and the following figures the Z or return wire is shown thicker, in order to make the diagrams clearer.

Simple bell circuit with "earth."—Fig. 141 is a simple bell circuit with "earth" connections, the circuit being completed between the two plates E E by the earth. The wire from the zinc of the battery, and one of the wires from the push, are fastened to the water-pipe in the manner described on page 9.

Two or more pushes to ring same bell.—Fig. 142 shows the method of connecting two or more pushes so as to ring the same

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FIG. 140.

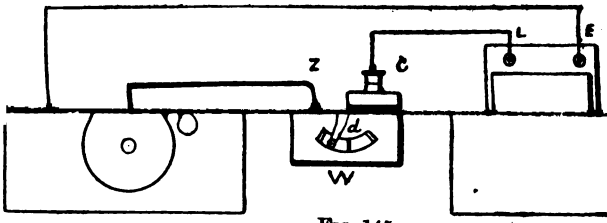


FIG. 141.

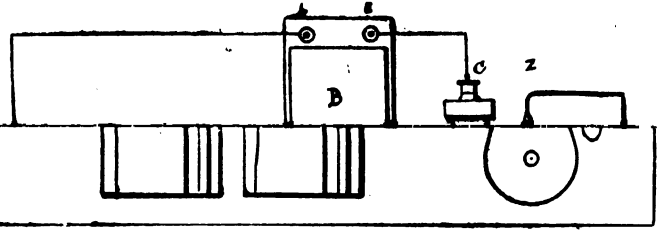
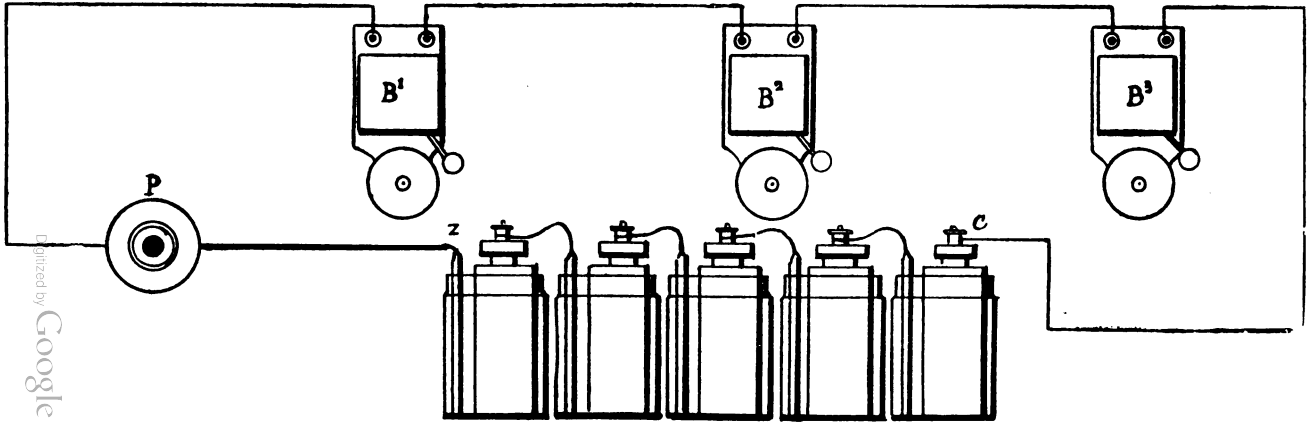


FIG. 145.



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bell. The pushes are here shown with their covers on, the buttons being represented by the black dots. Pressing the button of either of the pushes *a*, *b*, *c*, *d* completes the circuit, causing the bell B to ring.

Two bells to ring simultaneously from one push.—Fig. 143 shows an arrangement by means of which two bells can be rung simultaneously from one push, the bells being some distance apart, as in separate rooms. On the button of the push P being pressed in, the current flows from the positive pole C of the battery through the push, and along the wire *a* to *d*, where it divides, half (if the bells are of equal resistance) passing through the bell B, and half through the bell B′. When bells are arranged parallel like this, care should be taken to insure the resistance of the coils of each bell being as near alike as possible, or else to put the bell with the lowest resistance the farthest from the battery, so that the resistance of the line compensates for its lower resistance. If there are many bells, care must also be taken to provide sufficient battery power, the largest sized cells being used. The practice of splitting up a battery of smaller cells into two halves, and connecting the halves in parallel, is not advocated, unless absolutely necessary, it being far preferable to employ larger sized cells.

Two bells in separate rooms, either of which can be rung singly by means of a switch.—Fig. 144 shows a similar arrangement to that in the previous figure, only each bell is rung singly, the bells being, as before, in separate rooms. A two-way switch, W, of the form shown in Fig. 52, is used, being fixed near the push P. If the button of the push is pressed while the arm D of the switch W is in the position shown, the terminal *a* is connected to *c*, and the bell B will ring; but if the arm of the switch is moved over to the opposite side, the terminal *a* is connected to *b*, and if the push is now pressed the bell B′ will ring instead.

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Bells in series.—Fig. 145 shows how bells are connected in series, so that by pressing the push P the bells B^1, B^2, and B^3 can be rung simultaneously. The bells, to ring satisfactorily, must be either single-stroke or of the form shown in Fig. 57. The cells of the battery for this purpose (the size of which cells will vary according to the size and construction of the bells used) must be of sufficient number, connected in series, so as to obtain the E.M.F. necessary to force the required current through the high resistance necessitated by placing the bells in series.

Simple bell circuit with relay.—Fig. 146 shows an arrangement suitable for long distances, a relay being used to close the local bell circuit. The zinc of the battery and one of the wires from the relay are put to "earth." When the button of the push P is pressed in, the current flows from the positive pole C of the battery D, through the push to the wire *a*, and from there through the relay coils to "earth." The armature of the relay is thus attracted, closing the local bell circuit; the current flowing from the pole C of the local battery D through the bell to the insulated post P of the relay (see Fig. 84, page 57), and thence by the armature A and wire to the negative pole Z; the armature of the relay remaining down so long as the button of the push is kept in.

Ringing a number of bells by means of relays in series.—Fig. 147 shows how a number of bells may be rung simultaneously by employing relays to close the local circuit. When the button of the push P is pressed, the current flows from the pole *c* of the battery D to push P, and through the wire *a* to relay R^1. Through the relay coils of relay R^1 to wire *b*, and relay coils of relay R^2, and thence by wire *c* to earth; the other pole of the battery D being also put to earth. This attracts the armature of both relays, closing the circuits of both bells B^1 and B^2. So long as the circuit through the push

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P is kept closed, the armatures of the relays are held down, and the bells ring; any break and make of the circuit being exactly reproduced by the relays.

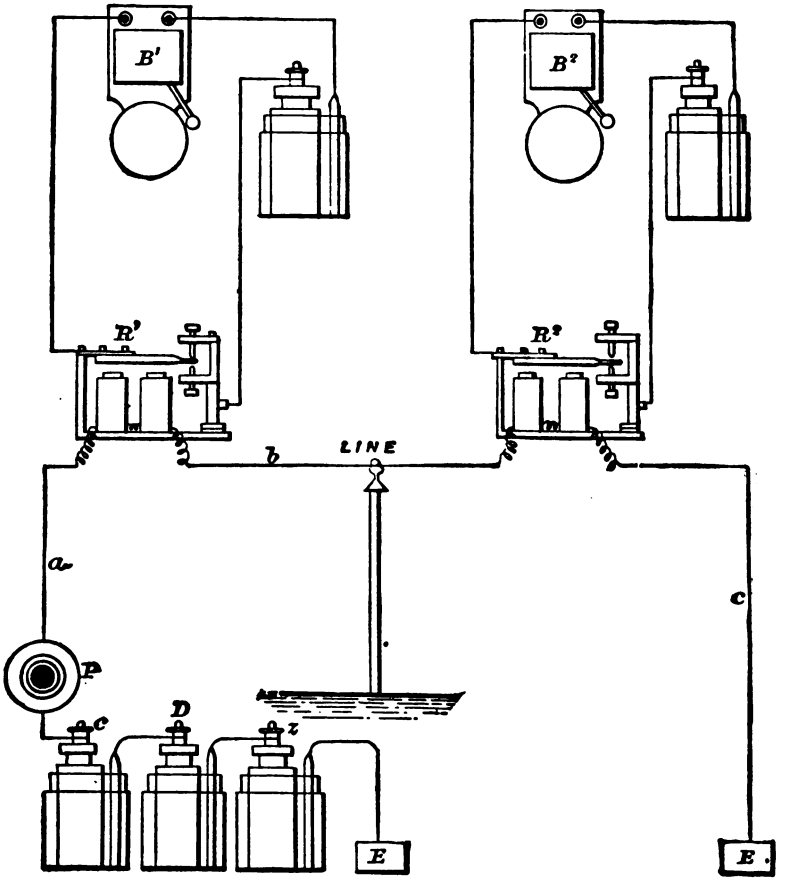

FIG. 147.

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Two sets of pushes working three bells by means of relays.—Fig. 148 shows an arrangement in which there are two sets of

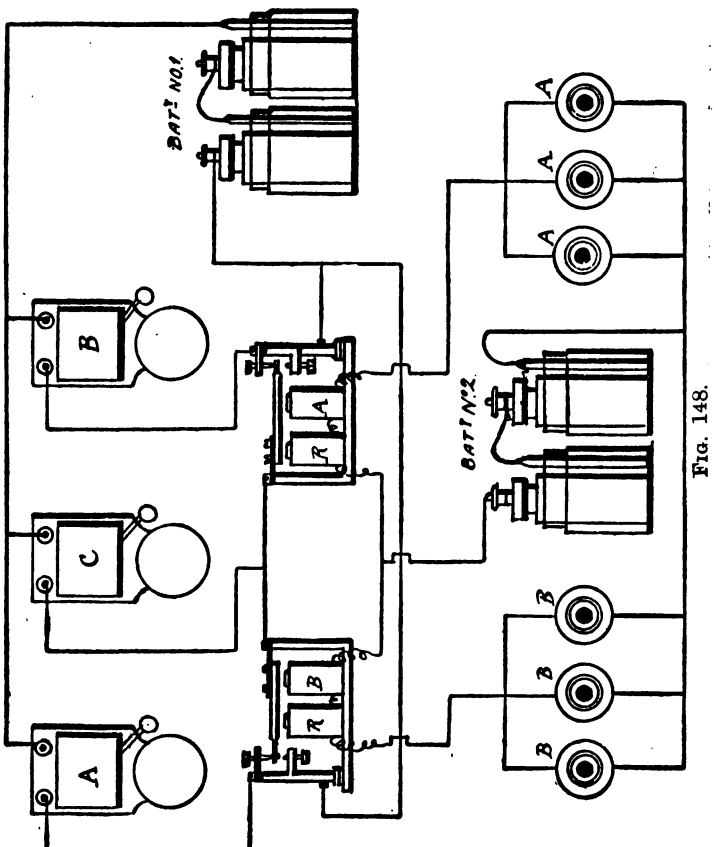

Fig. 148.

pushes and three bells. Any push out of one set will ring one bell, and any push out of the other set another bell, the

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third bell being common to both sets of pushes. Thus pushes A A A ring bells A and C by means of the relay R A, while

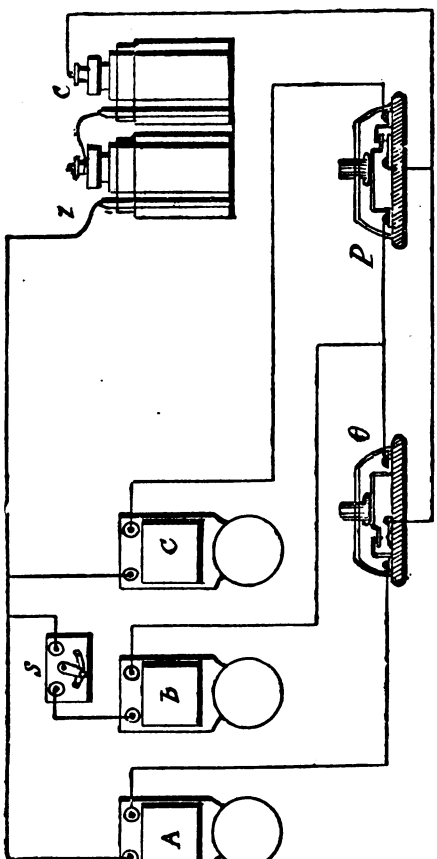

Fig. 149.

pushes B B B ring bells B and C by means of the relay R B. When the pushes B B B are pressed a current flows from

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battery No. 2 through the coils of relay B B, which thus attracts its armature, throwing the current from battery No. 1 on to bells B and C. The same action takes place when the pushes A A A are pressed, only with relay R A and bells A and C. Where one push only is required the arrangement shown in the following figure should be adopted, which does not necessitate relays.

Three bells and two pushes, each push ringing two of the bells, one bell being common to both pushes, which bell can be cut out with a switch.—Fig. 149 shows an arrangement in which push O will ring bells C and B, while push P rings bells A and B, but when the arm of the switch S is moved over to the opposite side to that shown in the figure, the bell B is cut out, push P ringing bell A by itself, and push O bell C by itself. Double contact pushes or Morse keys must be used for closing the circuits.

Continuous-ringing bell.—Fig. 150 shows the method of connecting up the continuous-ringing bells shown in Fig. 59, page 36. On closing the circuit by pressing the push P, the current flows from the pole C of the battery D to the terminal C of the bell, through the bell coils to L, and thence by the wire and push to the zinc of the battery. The lever being released on the first stroke of the bell, the local circuit through the bell is closed, the current flowing from C of the battery to terminal C of the bell, through the bell to terminal Z, and thence by the wire to zinc of the battery, the bell continuing to ring until stopped by pulling the cord at side.

Continuous-ringing bell with earth and local battery.—Fig. 151 shows the connections for a continuous-ringing bell when the circuit is very long, the ringing of the bell being continued after the original circuit is broken, by a local battery. The current in the main circuit flows (when the push is pressed) from the Pole C of the battery D, by the push and wire to

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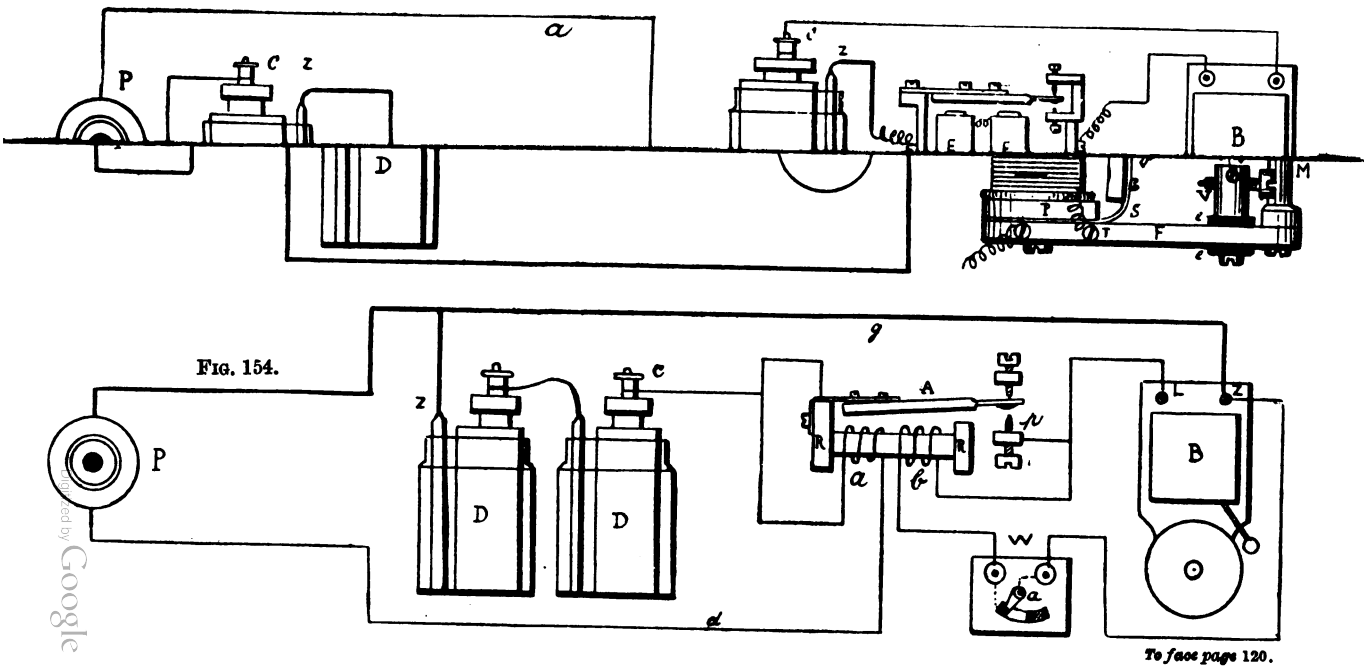

FIG. 154.

To face page 120.

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terminal L of the bell, and then through the coils to terminal Z and earth, the other pole, the battery, being also put to earth. The local circuit, after the bell is once started, runs from C of the local battery D to the terminal C, through the bell to terminal Z, and then by the return wire to the zinc of the battery, the bell continuing to ring until stopped in the manner previously described.

Bell made continuous ringing by an attachment to indicator movement.—Fig. 152 shows how an ordinary bell can be made to ring continuously by using an indicator constructed for such a purpose. Fig. 153 shows the indicator in detail: P P are the poles of the electro-magnet E, provided with an armature A, which when at rest is kept off the poles by the spring S. To the frame F is fixed the pillar M, the upper end of which carries the arm N in its normal position, supported by the catch T. A contact post R, fitted with a platinum pointed screw V, is also fixed to the frame F, but insulated therefrom by the washers *e e*. When a current flows through the coils of the electro-magnet, the armature is attracted, and the lever N slips off the catch T, causing the contact spring B to make contact with the screw V, thus connecting the insulated post R to the frame. The arm N (the face of which is painted white so as to show through the perforation in the dial of the indicator) is reset by pulling a cord at the side, which throws up the arm, causing it to again engage with the catch.

When the push P, Fig. 152, is pressed, the current flows from C of the battery to the frame F of the indicator; thence, by screw J and wire, through the coils of the electro-magnet (attracting the armature and releasing the arm) and then by wire and push to the zinc of the battery. The current now flows from C of the battery to the frame of the indicator, pillar M, arm N, contact post R, thence by wire to the terminal L of the bell, through the bell to terminal Z, and then by the wire to

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the zinc of the battery, the bell continuing to ring until the indicator is reset.

Callow's continuous-ringing attachment for electric bells.—In Callow's continuous-ringing attachment for electric bells, which was referred to on page 37, an ordinary relay is used in place of the drop relay shown in Fig. 84, page 57. This is connected to the bell in the usual way, but with this addition—the coil *b* of the relay is so connected as to form a shunt circuit across the terminals of the bell. It will be seen from this, that on the armature of the relay being attracted and a current flowing through the bell, part of the current is shunted through the relay, thus keeping the circuit closed. In adapting this attachment to bells already working with a relay, the relay is wound with two wires, the primary or first layer being connected direct to line, and the secondary or second layer in the shunt circuit. This arrangement is shown in Fig. 154. When the button of the push P is pressed, the current in the main circuit flows from the positive pole C of the battery D, through the coil *a*, and thence by the wire *d* and push P to the zinc of the battery. This attracts the armature A of the relay R, closing the local bell circuit, the current flowing from C of the battery to armature A of the relay R, contact post *p*, terminal L of the bell, through the bell to terminal Z, and thence by wire *g* to the zinc of the battery. Part of the current also flows along the wire from the bell terminal L, through the relay coil *b* and switch W, to terminal Z of the bell, thus keeping the armature of the relay down after the main circuit has been broken, the bell continuing to ring until the shunt circuit is broken by moving the arm *a* of the switch W over to the opposite side. The bell can also be stopped by short circuiting the relay, which can be effected by an ordinary push.

It will be seen that more than one bell can be rung from

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the same attachment, and the bell can, by moving the arm of the switch W, be made continuous ringing or not, at will. If the arm *a* of the switch is moved over to the opposite side to which it is shown in the figure, the shunt circuit of the bell through the relay is broken and the bell will ring only so long as the button of the push is kept in. This continuous-ringing attachment is very convenient for front doors, &c., where trouble is often experienced in securing immediate attention to the summons. Instead of being taken to the switch as in Fig. 154, the two wires are taken to a contact (see Fig. 106) fixed on the side of the door frame, and so arranged that, when the door is opened, it either short-circuits or breaks the shunt circuit; thus, when the push is pressed, the bell rings until the door is opened, the continued ringing of the bell insuring prompt attention.

Bell ringing either as a vibrating or single-stroke one.—Fig. 155 shows an arrangement in which, by means of a switch fixed near the push, the bell can be made vibrating or single-stroke at will. The bell B (shown with its cover removed) is an ordinary vibrating bell, but with an additional terminal S fixed between the original terminals and connected to the frame by means of a screw. If the push is pressed while the arm *a* of the switch W is in the position shown, the bell will ring as a vibrating bell; the current flowing from the pole C of the battery to terminal L of the bell, through the bell coils E E to contact post P and terminal Z, thence by wire *d* to terminal *b* of the switch, and from there by arm *a*, wire *g*, and push P to the zinc of the battery. If the arm of the switch is moved over to the opposite side, and the push pressed, the bell will ring as a single-stroke bell; the current now flowing from C of the battery to terminal L, through the bell coils to screw J and terminal S, thence by wire *f* to the terminal *c* of the switch, and from there by arm *a* and push P

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to the zinc of the battery. The bridge *n* in the wire *a* indicates that the wire *d* passes over the wire *g*, and is not connected to it in any way.

Signalling in both directions with three wires and one battery.—Fig. 156 shows how the bells and pushes must be arranged for signalling in both directions with three wires and one battery. Pressing the push P rings bell B, while pressing push P′ rings bell B′. The circuit (when the push P is pressed) is from the pole C of the battery, wire *a*, push P, wire *b*, bell B, and zinc of the battery. The circuit through the other push is from the pole C of the battery, wire *a*, bell B′, wire *c*, push P′, and zinc of the battery.

Signalling in both directions with one wire and two batteries.—Fig. 157 shows an arrangement for signalling in both directions with one wire and two batteries, double contact pushes of the form shown in Fig. 14, being used. Pressing push P causes bell B to ring, and the bell B′ is rung by pressing the push P′. The wire marked "line" is the wire which (taken overhead or underground) runs between the two stations. Having looked at Fig. 14, and read the description on page 14, it will be seen, on referring again to Fig. 157, that pressing the button of push P puts the positive pole C of the battery D to line, the circuit through bell B being as follows: Pole C of the battery D, wire *a*, bottom contact and spring of push P, line, spring, and top contact of push P′, wire *b*, bell and "earth"; the other pole of the battery being also put to "earth." The circuit closed by pressing push P′, is from battery D′, wire *d*, bottom contact and spring of push P′, line, spring, and top contact of the push P, wire *g*, bell and "earth"; the other pole of the battery D′ being likewise put to "earth." A Morse key is frequently used instead of the push shown, though, of the two, for general purposes, a good substantially made double contact push is much to be preferred.

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Fig. 155.

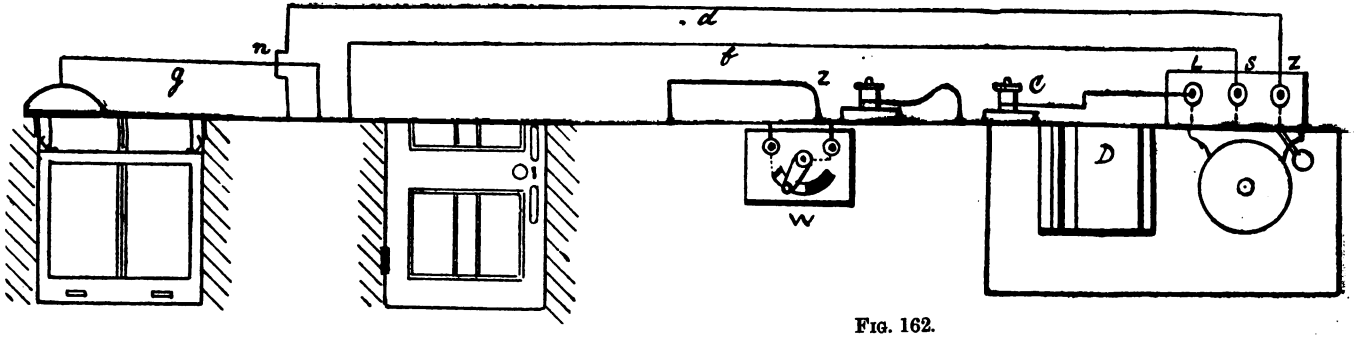
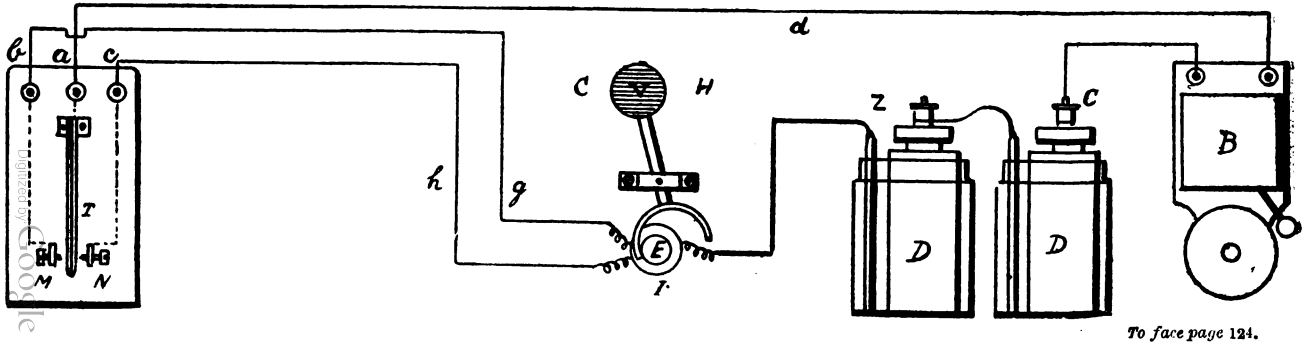


Fig. 162.



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Connecting-up burglar alarm contacts.—Fig. 158 shows how burglar-alarm door and window contacts should be connected-up, a window and door being shown so connected. The door is protected by a contact of the form shown in Fig. 106, the top sash by the form shown in Fig. 107, and the bottom sash by contact springs at the side. Opening either the window or the door closes the circuit, causing the bell to ring; the action that takes place being the same as that described for Fig. 150. The switch shown at W is for the purpose of breaking the circuit in the daytime, so that the ordinary opening and shutting of the windows will not ring the alarm bell. By a slight addition to the hall clock, it may be made to break the circuit in the day and close it again at night, thus doing away with the necessity for a switch, which is very often liable to be forgotten. A modification of this arrangement (Fig. 158) is much used in factories, &c., to insure all the windows being shut before the premises are closed for the night. Instead of the continuous-ringing bell shown in the figure being used, a small vibrating bell is substituted. The bell will ring, should any of the windows be open, when, as a test, the arm of the switch W is moved into the position shown.

Closed circuit ringing without relay.—A better means, however, of protecting the windows and doors than by the method shown in Fig. 158 can be obtained by employing what is known as the "closed circuit system." It will be seen by glancing at Fig. 158, that if either of the wires leading to the contact on the door are cut or otherwise severed, the contact on that door is rendered quite useless, and the door can be opened and shut without in any way affecting the alarm bell. But on the closed circuit system, as the alarm bell is started by opening the circuit, any cutting of the wires at once starts the bell, giving an alarm. There are two different ways in which the closed

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circuit system may be caused to give the alarm, 1st, by employing a special bell, working off the same battery as that which works the contact, or 2nd by employing a relay and a continuous-ringing bell, worked by a local battery. Fig. 159 shows a safe fitted with a burglar alarm on the closed circuit system, by the first method. In the figure, D is the battery (a gravity

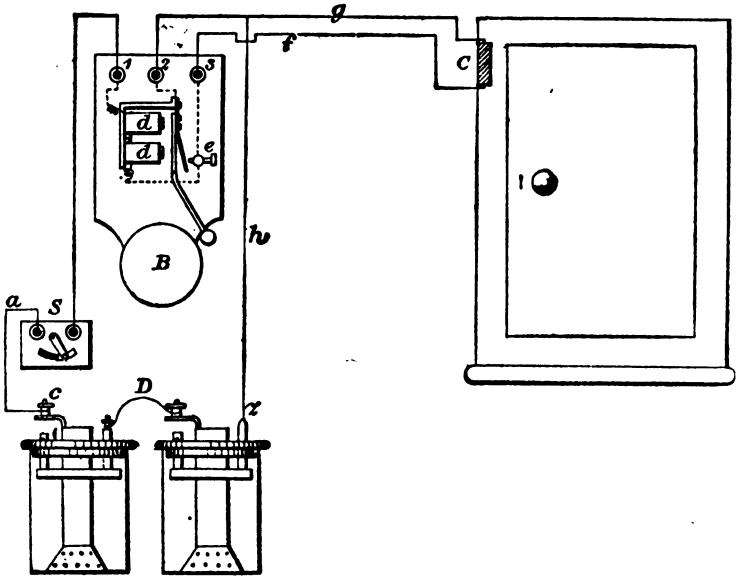

FIG. 159.—CLOSED CIRCUIT SYSTEM.

Daniell), C the burglar contact on the safe, S the switch for cutting off the alarms when not required, and B the bell. This bell is an ordinary vibrating bell, fitted with a third terminal on the right-hand side of the base, which terminal is connected to the contact post *e*. A special form of burglar contact is used (shown in detail in Fig. 160) which *breaks*, and

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not *makes*, the circuit when the pressure is removed from the button *b*. So long as the circuit through the contact C is closed a current flows from the pole C of the battery D to wire *d* and switch S, and then through the switch to terminal 1 of the bell. From this terminal it flows through the magnet coils *d*, to contact post *e*, terminal 3, wire *f*, contact *c*, wire *g*, to the zinc of the battery. This magnetises the magnet cores, causing them to attract the armature of the bell, holding it against the poles. Thus the armature is pulled away from the contact post, and retained in that position until the circuit is broken by the safe door being opened or the wires to the contact severed. When this takes place the armature of the bell falls

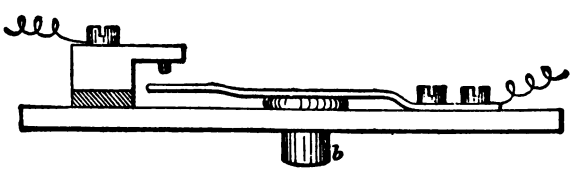

FIG. 160.—CLOSED CIRCUIT CONTACT.

back against contact post *e*, the bell continuing to ring until the switch W is moved. The circuit through the bell is as follows:—Pole C of the battery D, terminal 1 of the bell, through the bell coils to contact post *e*, armature, terminal 2, and by wire *h* to the zinc of the battery.

Closed circuit ringing with relay.—Fig. 161 shows a safe fitted with a burglar alarm on the closed circuit system by the second method. R is the relay, D the main battery (a gravity Daniell) and C the contact on the safe, E is the local battery (Leclanché) B the bell, fitted with a continuous-ringing attachment, and S the switch for cutting off the alarm bell. When the door of the safe is shut the circuit is as follows:—Pole *c* of the battery D, wire *a*, relay coils, wire *b*, contact *c* and zinc of the battery.

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This attracts the armature of the relay, causing it to break contact with the contact screw *e*. If, now, the circuit is broken the armature is released and makes contact with the screw *e*, which closes the local bell circuit, the current flowing from the positive pole P of the battery E, to switch S, terminal G of bell B, through the bell to terminal L, wire *f*, armature of

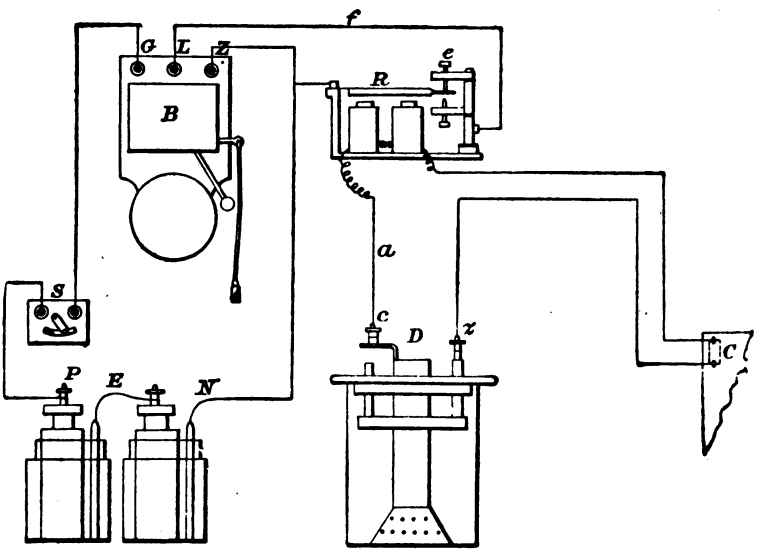

FIG. 161.—CLOSED CIRCUIT SYSTEM WITH RELAY.

relay, contact screw *e*, to negative pole N of the battery. This releases the catch on the lever of the bell B, which continues to ring until the switch is shut off.

This last described method is to be preferred to the former, as it will be seen on inspecting Fig. 159 that the alarm bell will cease ringing if the safe door is closed again, which is not the case in the second method. The advantage of the *closed*

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over the *open* circuit system is very great. In the "open circuit," the only means of knowing whether each contact is in order is by actually testing each one, but in the "closed circuit," should the contact fail to close the circuit when the door or window is shut, an alarm is immediately given. It is often recommended to leave the wires exposed to view as much as possible in the closed circuit system, as it is very probable that the burglar would make a point of cutting all suspicious looking wires he came across, and so giving an alarm. But it is obvious that if he can cut, he can also join them together, thus rendering the contact useless. Therefore, if only one system is used, it is always best to carefully conceal the wires. The most perfect alarm is obtained by combining the two systems, *id est*, having two contacts on each door or window, one contact on the closed, and the other on the open circuit system. Then, if the wires are exposed to view, an alarm will be given whether the wires are cut or short-circuited. It will be noticed that in the closed circuit the different contacts must be placed in *series* and not in *parallel*, as in the open circuit system.

Connecting-up hothouse alarm.—Fig. 162 shows a method of connecting-up the hothouse alarm shown in Fig. 112. The indicator I (the electro-magnet E of which is wound with two coils) is included in the circuit, in order to show whether the bell rings, because the house is too hot or too cold. The indicator is shown in detail in Fig. 94. The bell, battery and indicator are generally fixed in the attendant's cottage. The action of the alarm is as follows:—When the temperature falls below a predetermined point, the tongue T touches the contact screw M, closing the circuit, the current flowing from the pole C of the battery D, through the bell to wire *d*, terminal *a* of the alarm, tongue T, contact screw M, terminal *b*, wire *g*, one of the coils of the electro-magnet E (throwing the vane over

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into the position shown), and then to the zinc of the battery. Any rise in the temperature causes the tongue T to touch the contact screw N, closing the other circuit; the current now flowing from the pole C of the battery to the terminal *a* of the alarm as before, tongue T, contact screw N, terminal *c*, wire *h*, through the other coil of the electro-magnet E (throwing the

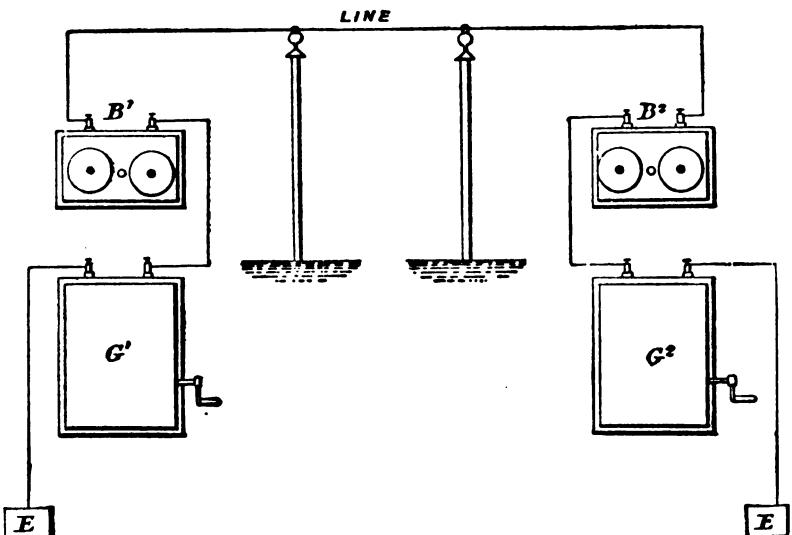

FIG. 163.—CONNECTIONS FOR MAGNETO BELLS.

vane over to the opposite side), and then to the zinc of the battery. Two bells of different tone are sometimes employed instead of the indicator shown, or the alarm may be made to act direct on to the ventilating apparatus.

Connecting-up two magnetos.—Fig. 163 shows how two magnetos should be connected-up. One terminal of each generator is put to earth, the other being connected to one terminal of the bell. The other terminal of the bell is put to line. Thus

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when the handle of generator G′ is turned, the current flows from the armature of the generator to bell No. 1, line, bell No. 2, generator No. 2, to earth, and from earth back to the armature of the generator, there being a current first in one direction and then in the other. The same action takes place when the handle of generator No. 2 is turned. Both bells ring when the handle of either generator is turned, the bells being in series. Any number of magneto bells, provided the generator is strong enough, can be placed in series, without the ringing of the one interfering with that of the others.

Connections for indicator.—Fig. 164 shows the connections for the indicator shown in Fig. 93. The circuit through the indicator when either of the pushes P^1, P^2, P^3, &c., are pressed is from the pole C of the battery, through the magnet coils of the movement corresponding to the push that is pressed, push, and then by the return wire to the zinc of the battery. If a relay is employed, as in the indicator shown in Fig. 99, the current of course does not go direct to the bell, but passes through the relay coils to battery.

An indicator and bell with extra bell for front door push, the front door push ringing either one bell or two by means of a switch. —Figs. 165 and 166 show two methods by means of which the push T may be made in the daytime to ring both bells A and B, but at night only A. In Fig. 165 the pushes P^1, P^2, P^3 will in the daytime also ring top bell A, but in Fig. 166 they do not. In both diagrams A is the bell at the top of the house, H the indicator, and B the bell working in conjunction with it. P^1, P^2, P^3 are the house pushes, and T the push at the hall door. When the arm of the switch S is in the position shown, bells A and B will ring if the push T is pressed; but they will also ring if pushes P^1, P^2, P^3 are pressed. If the arm of the switch is moved over to the other side, push T will only ring A, and pushes P^1, P^2, P^3 only B. In Fig. 159, however,

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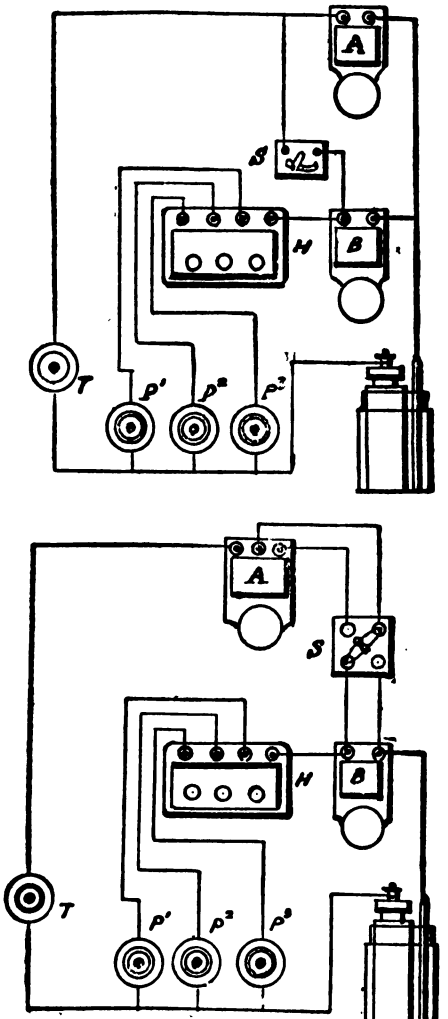

FIGS 165, 166.

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if the arm of the switch S is in the position shown, push T will ring bells A and B, while pushes P^1, P^2, P^3 will ring B only. If now, the arm of the switch is moved over to the other side, the other two contacts are connected, and push T will only ring bell A, while pushes P^1, P^2, P^3 will ring B as before. In Fig. 166 S must be a four-point switch, the working of which will be clearly seen from the figure, and the bell A must be of the form shown in Fig. 155, being an ordinary trembling bell, with a third terminal fixed between the original terminals and connected by a screw to the frame (see Fig. 155). When the switch S is in the position shown, and the one in which it would be in the daytime, A is a single-stroke bell in series with B, which thus makes and breaks the circuit for it; but if the arm of the switch is in the opposite position, A is made a trembling bell and B is cut out of its circuit.

A few diagrams will now be given, showing the most usual methods adopted when fitting up the various apparatus in private houses, hotels, and similar buildings.

Private house circuit; pushes ring downstairs only.—Fig. 167 shows the arrangement generally adopted for a small private house, there being a push in each room to ring downstairs, and one in the hall for the call bell. The push N rings the call bell B^2, while the pushes P^1, P^2, P^3 ring the bell B^1 through the indicator H, which is of the simple form, working without a relay. In wiring the house, a main or battery wire *m* (shown darker for distinction) is run up to one of the terminals of the call bell, branching off to the pushes P^1, P^2, P^3 as it passes. A separate wire is then run from each of the pushes to the corresponding terminal of the indicator. Another wire *r* is also brought down from the other terminal of the call bell to the push N, being cut here and then continued on to the other pole of the battery; the current through the indicator also effecting a return to the battery by the lower portion of this wire.

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Private house circuit; pushes ring both up and downstairs.—Fig. 168 shows an arrangement used in large private houses when it is desired to be able to ring upstairs as well as downstairs, two pushes being placed in each room for this purpose. Pushes P^1, P^2, P^3 ring downstairs, while pushes T^1, T^2, T^3 ring upstairs. An indicator H and bell B are placed both at the top and bottom of the house, the indicator being of the form described for the previous figure. When wiring, a main wire *m* is run (as before) from one pole of the battery to the farthest push, and branches taken off at the most convenient points to the remaining pushes. A separate wire is then run from each of the pushes, those that come from the pushes that are to ring upstairs going to the top indicator, and the others to the bottom one. A return wire *r* is also run from the other pole of the battery to the top bell, branching off to the bottom bell as it passes. The front and back doors should preferably ring on to separate bells instead of the ordinary house bell; though, if the expense is objected to, they can, of course, be put on to the indicator. As to which pole of the battery the main wire from the pushes should be attached, provided the insulation is good, it does not matter which; but, as it is best to keep to one way of wiring, it is advisable to conform to the conventional method of attaching it to the positive.

Finishing of an Electric-Bell Installation.

After the building has quite left the painters' and paperhangers' hands, the pushes, bells and indicators must be fixed, a final test being made with the galvanometer to see that the wires are still in the same condition as when left at the completion of the wiring. When connecting-up the pushes, care must be taken not to overturn the screws under which the wires are fixed, for with the majority of pushes as sent out

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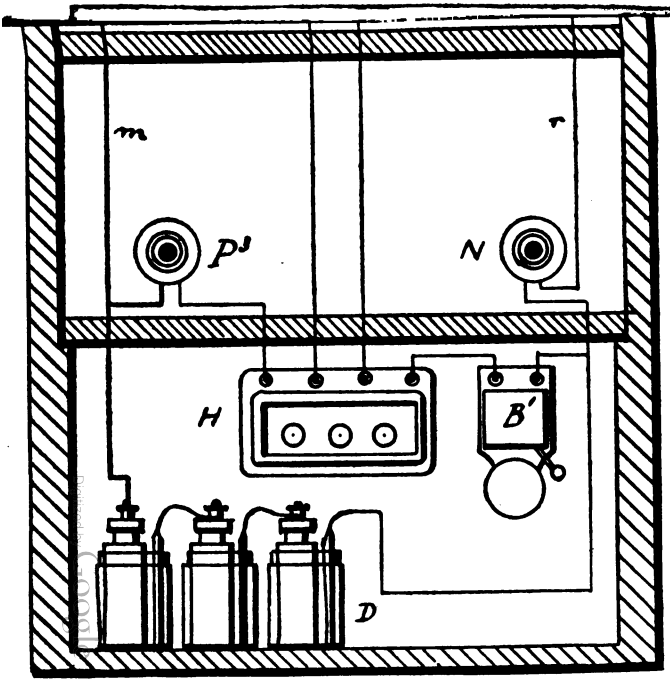
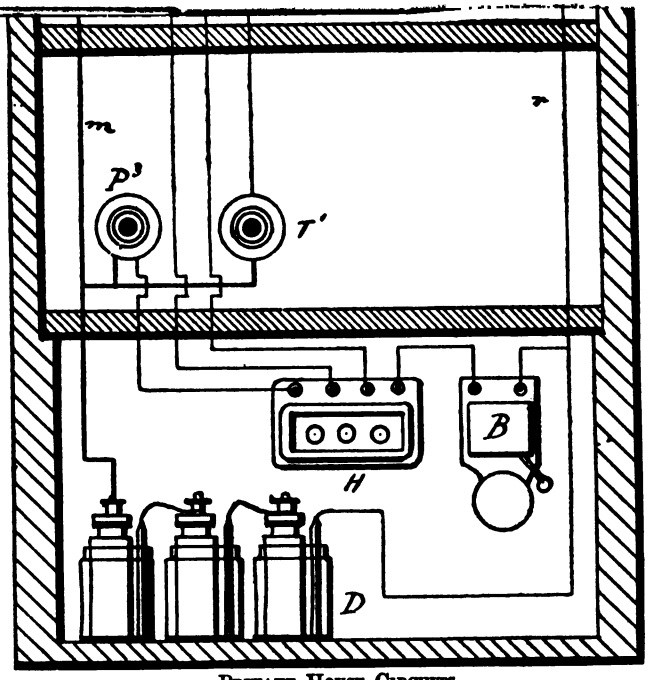


PRIVATE HOUSE CIRCUITS.



PRIVATE HOUSE CIRCUITS.

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the screws are very small, and generally screwed down hard; consequently when the screws are slacked out and the wires placed under them it is very rarely they will bear the turning necessary to get good contact. If the pushes are hard wood and the screws small, it will amply repay to take out the small ones, re-drill, and put in larger ones. Before cutting off the ends of the wires to connect to the push, a little of the slack should be worked back into the tube, thus allowing of the connection being made again should it break at any future time. The pushes having all been connected-up, the next thing is to fix the bell and indicator. In this country the general practice is to place the bells with the gongs downward, though it is obvious they will work equally well in any position. A bell, however, adjusted for ringing in one position, will, of course, require fresh adjustment if fixed in another. The best place for the bell that works in connection with the indicator is just above the indicator, which, like the bell, must be screwed to a wood block fixed at the time the house was wired.

Nothing looks so bad as a bundle of wires all twisted and hanging about loosely, and if there has been any slovenly wiring in a house it will always be found in its most violent form at the indicator. The tubes carrying the wires should either end behind the indicator, and the wires brought over to the top and fastened to their respective terminals, or else, if the battery is in a cupboard near, the tubes should end in the cupboard, and the wires continued on the indicator, tied up into a neat cable. A very good way, however, and the one adopted by the author, is to stop the tubes just beneath the ceiling above the indicator, and then to run a light, flat casing, neatly stapling the wires down inside in the order that they come out of the tubes. This method, besides having a very neat appearance, allows of the various circuits, so far as they

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branch off into the tubes, being inspected at a glance. Having fixed the indicator bell, and brought all the ends of the wire to the indicator, nothing now remains but to fix the right wires under the different terminals of the indicator. To do this, the battery (having been previously charged) must be put into its proper position and connected-up. The assistant must then be sent to the different pushes in succession, going from room to room in a pre-arranged order. At each room he holds the button of the push till he gets the signal to leave go, when he proceeds to the next. Whilst the assistant is pressing the push, the ends of the wires must be touched in succession on any terminal of the indicator till the bell rings, when the wire that causes the bell to ring must be inserted under that terminal of the indicator which corresponds to the room the assistant is in. A small metal wedge should be included in the fitter's outfit, which (if no assistant is at hand) can be inserted between the springs of the push to close the circuit.

Arrangement of the circuit for hotels, &c.—For hotels and other large establishments the arrangement shown in Fig. 169 is usually adopted, as being more convenient than using one big indicator, which would in addition necessitate running the whole of the wires to the ground floor. The indicator H on the ground floor merely indicates from which floor the summons has been sent, while the indicators H^1, H^2, H^3 and H^4, placed on the respective floors, indicate the particular room. A bell and indicator are placed on each floor, the indicator being of the pendulum movement form and having a relay inside to close the bell circuit.

Suppose, now, the push P^1 fourth floor is pressed, the circuit through the push is as follows:—Pole C of the battery D, main wire *m*, push P^1 fourth floor, terminal 1 of the indicator H^4, magnet coils of the movement, relay coils, terminal Z of the indicator, wire *r*, terminal 4 of the indicator H, magnet coils of

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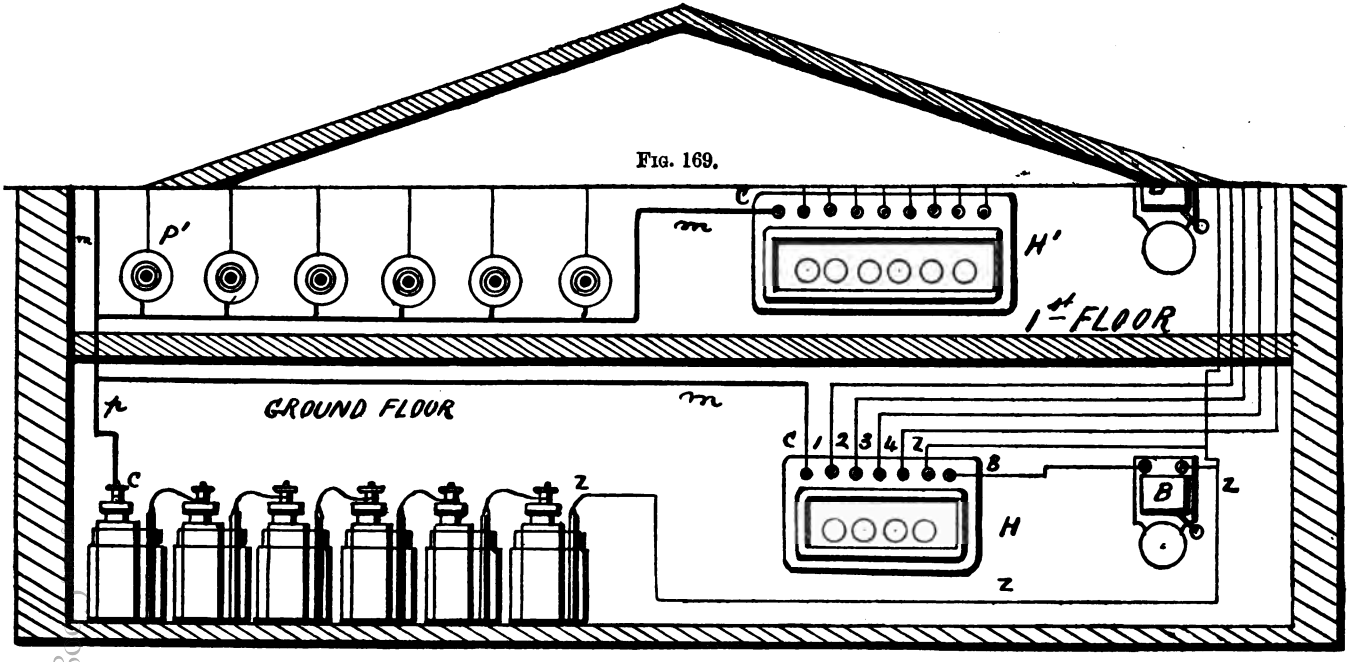
Fig. 169.



Circuit for Hotels and Large Buildings.

To face page 186

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movement, relay coils, terminal Z of the indicator, wire Z, and zinc of the battery. This attracts the armatures of the relays in the indicators H and H^4, causing the bells B and B^4 to ring. The circuit through the bell B^4 is from the main wire *m* to the terminal C of the indicator H^4, relay armature, terminal B of indicator, bell B^4, wire Z, and zinc of the battery. The circuit through bell B is from main wire *m*, terminal C of the indicator H, relay armature, terminal B, wire Z, and zinc of the battery. If push P^2 third floor is pressed, the same action takes place, only with indicators H^3 and H instead of H^4 and H. The action is, of course, the same for the rest of the pushes, only with different terminals of the indicator.

It is in a case like this, that a good, substantially made pendulum indicator is so much to be preferred to any kind that requires a shutter or vane to be replaced by the attendant before it can be used again, as with the almost incessant ringing of bells in a large hotel the most careful of servants will repeatedly forget to replace the shutters.

The main wire (shown darker) from the pushes is, in the diagram, taken to the positive pole of the battery, and to this pole, provided the wiring has been done in a substantial manner, it is, as was previously stated, advisable to put it. On referring to the diagram, however, it will be seen that if the main wire *m* is broken—let us say, at the point X, the top indicator, with all its dependent pushes, will be disconnected, and the further down the rupture occurs, the more pushes and indicators are cut out, until a rupture in the wire at *p* will cause a break-down in the communication throughout the entire building. Now if, in a badly-wired building, where the insulation of the wires is poor, staples have been injudiciously used, and the situation of the wires is naturally damp, a continual leakage takes place between the wire *m* and all the remaining wires. By the electrolytic action of the current

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the copper is eaten away from the main wire, the main wire getting thinner and thinner until a jar or variation in the temperature causes the final separation, stopping all communication.

Thus, in the case of a large hotel where the insulation has broken down, and owing to the place being full it is not convenient to at once remove the faulty wires, the rupture of the main wire may be prevented by simply reversing the battery connections, by this means putting zinc to the main wire. The action on the main wire now ceases, and if a rupture occurs it will be in one of the other wires, which will only affect that push or bell to which it happens to be attached. This continuing of the communication is, of course, only at the expense of the battery, and the faulty wires must be renewed as soon as possible.

The front and back door bells would, of course, be separate from the system of bells from the various rooms, and likewise the communication with the lift next to be described.

Communication with the lifts.—In hotels and similar buildings, some method of communicating with the lift, by means of which a person can signal to the attendant and receive an intimation that the summons has been heard and will be attended to, is an absolute necessity. For this purpose nothing can be so readily adapted, or will so fulfil all the necessary conditions, as a good system of electric bells. There are two systems that can be adopted—1st, that in which naked copper wires and contact springs are used for making connection with the lift-cab; and, 2nd, that in which (with the same object in view) a flexible cable is employed. Of the two, the first has perhaps a slight advantage over the second in the matter of cost, but the difference is trifling, and much will depend on the selection of the particular system, on the construction of the lift, and the space at one's disposal

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As the difference between the two systems consists merely in the manner in which connection is made between the fixed wires and the movable cab, the connections of the various bells, pushes, &c., will be the same in each, so that a description of the one will refer equally to the other. In either system, then, a push and bell are required on each floor, and a bell and indicator must be fixed in the lift-cab, the indicator having as many "drops" as there are floors. This indicator must be of such design that the ordinary stopping and starting of the lift will not jolt over the vane or release the shutter. For this reason pendulum indicators such as employed for house work are useless for this purpose; therefore either mechanical movements or some such form as shown in Figs. 170 and 171 must be adopted. This is the ordinary telephone indicator, such as is used in telephone exchanges, and consists of an electro-magnet, *e e*, firmly screwed to the frame *f*, to one end of which is pivoted the shutter *s*. Above the magnet *e e* is the armature *a*, pivoted at *g*, and fitted at one end with the catch *c*, which engages with the shutter *s*. When the current passes through the coils of the electro-magnet its armature is attracted against the pressure of the spiral spring *t*, and the catch moves upwards, releasing the shutter, which falls over outward by reason of its being set a little out of the perpendicular, thus disclosing the number printed on the card *h*. The tension of the spiral spring *t* can be adjusted by the milled screw *m*. Fig. 170 is a side view of the indicator, and Fig. 171 a front elevation with the shutter down. Fig. 172 shows the lift-cab fitted with a bell, and a four-drop indicator of the form just described. Reply keys are also shown at the bottom of the indicator, and likewise the connections to the springs on the top of the cab.

When fitting up the lift on the first-mentioned system, a stout oak block (Fig. 173) must be fixed both at the top and

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bottom of the lift-shaft, and the naked copper wires, one for each floor and one for each pole of the battery, stretched from top to bottom, the ends of the wires being fixed by metal pegs, after the manner employed for piano wires. The best method of fixing the pegs and wires is by employing the lift itself. Having got the wires and pegs together, get on top of lift-cab and send it up to the top of the shaft till the top block is well within reach. Mark off on the block six points, leaving two inches between each point and two inches between the outside points and the ends of the block. Now with a gimlet slightly smaller than the metal pegs bore a hole at each of the marks, and drive in a peg, giving each peg two or three turns so as to cause it to bite. Next insert one end of the coil of wire (No. 14 B.W.G. uninsulated) in the hole in the end of the peg, taking two or three turns round it, and then having seen that the coil is likely to run out freely, start the lift slowly downwards, paying out the wire as it descends, till the bottom block is reached, when the wire must be cut off, and the remaining wires brought down in a similar manner. When all the wires have been brought down, the bottom block must be marked off, bored, and pegs driven in after the manner described for the top block, and the ends of the wires put into the holes in the ends of the pegs. The pegs must then be turned round, tightening up the wires until they begin to stretch, when they will be perfectly tight. Care must be taken that the wires are quite parallel with the traverse of the lift, or the springs will not ride easily. If the lift has been properly erected, it will be sufficient to hang a weight on the bottom of the first wire, after it has been fixed at the top, and a mark made where it hangs, the others being marked off from this point.

The wiring of the lift-shaft having been completed, the next thing is to run the wires from the pushes and bells on the respective floors to the shaft, joining them into the wires that

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Fig. 170.

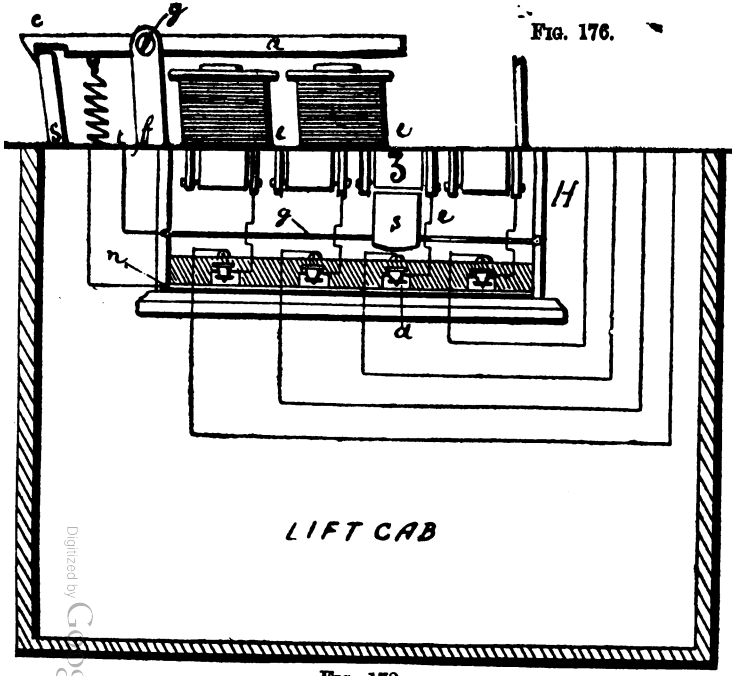

Fig. 172.

Fig. 176.

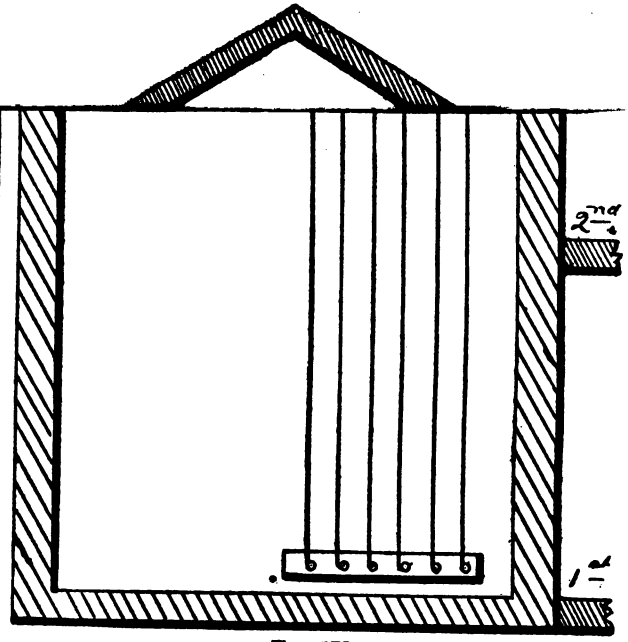

Fig. 173.

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have been stretched from top to bottom. Fig. 175 shows the arrangement of the various apparatus, there being a bell and double contact push on each landing, which pushes were shown in detail in Fig. 14, page 14. When wiring, a wire is first run from the bottom contact of each push to the lift-shaft joining into the wire *c* that is connected to the positive pole of the battery. A wire is next run from the top contact of each push to one terminal of the bell on the same landing, being continued on from the other terminal to the shaft, and joined into the wire *z*, which is in connection with the negative pole of the battery. A wire is also run from the spring of each push, and joined into the shaft wire corresponding to the landing from which it comes.

As it is very seldom that a good fixing is to be obtained for the wires in the lift-shaft, it is well, when fixing the shaft wires as described above, to select for this purpose the side of the shaft nearest to the pushes, so as to shorten, as much as possible, the distance through which the wires from the pushes must be run. If, however, space does not permit this, the wall must be "plugged" at such places as it is necessary to obtain a fixing, and the wires stapled to the wooden plugs. In joining the wires from the pushes and bells into the shaft wires, the connection must be made at the back of the shaft wires, so that the joints will not interfere with the contact springs, as they move up and down with the lift. Fig. 174, which is a side view, shows how this should be done. The end of the wire B from the push, is turned up and soldered on to the shaft wire A, which, if properly done, should leave no solder on the front of the wire, thus securing a smooth surface for the spring. The wire B must be fixed at the point where it leaves the wall to join the shaft wire, so as to prevent the joint coming to the front should the wire A have a tendency to twist at any future time.

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In order to follow out the circuits, Fig. 173 must be imagined placed in the lift-shaft of Fig. 175, the springs (1, 2, 3, 4, *c*, *z*) on the top of the lift-cab coming over their respective shaft wires, with which they would in actual practice maintain a rubbing contact. Pressing either of the pushes, P^1, P^2, P^3 or P^4 will ring the bell B in the lift-cab, and release the shutter of the indicator corresponding to the floor from which the signal has been sent, while pressing the keys at the bottom of the indicator H will ring the bell fixed on different landings. Suppose, for instance, push P^3 on the third landing is pressed, the circuit closed, by pressing in the button, is from the pole C of the battery D, shaft wire C, wire O, bottom contact of push P^3, push-spring, wire *p*, shaft wire 3, spring 3 on top of lift-cab, wire C, key *d* at the bottom of indicator H top contact, wire *e*, coils of indicator No. 3, framework of movement, wire *f*, spring Z on top of cab, shaft wire Z, and zinc of the battery. This attracts the armature of movement No. 3 of the indicator H, throwing down the shutter, as shown in the figure. The shutter falls on to the copper rod *g*, causing the bell B to ring, the circuit closed being as follows: pole C of the battery D, shaft wire *c*, spring *c*, wire *m*, bell B, wire *g*, rod *g*, shutter S, frame of movement 3, wire *f*, spring Z, to zinc of the battery. The bell continues to ring until the shutter is replaced by the attendant, which breaks the bell circuit. He then presses the key *a* at the bottom of the indicator H, which makes contact with the brass plate *n*, causing the bell B^3 on the third landing to ring; the current flowing from the pole C of the battery to the shaft wire *c*, spring *c*, wire *m*, brass plate *n*, key *d*, wire *c*, spring 3, shaft wire 3, wire *p*, push spring, top contact of push P^3, wire *r*, bell B^3, wire *t*, shaft wire Z, and zinc of the battery. The same action takes place if any of the other pushes are pressed, only with different movements of the indicator H; and different keys must, of course, be used for

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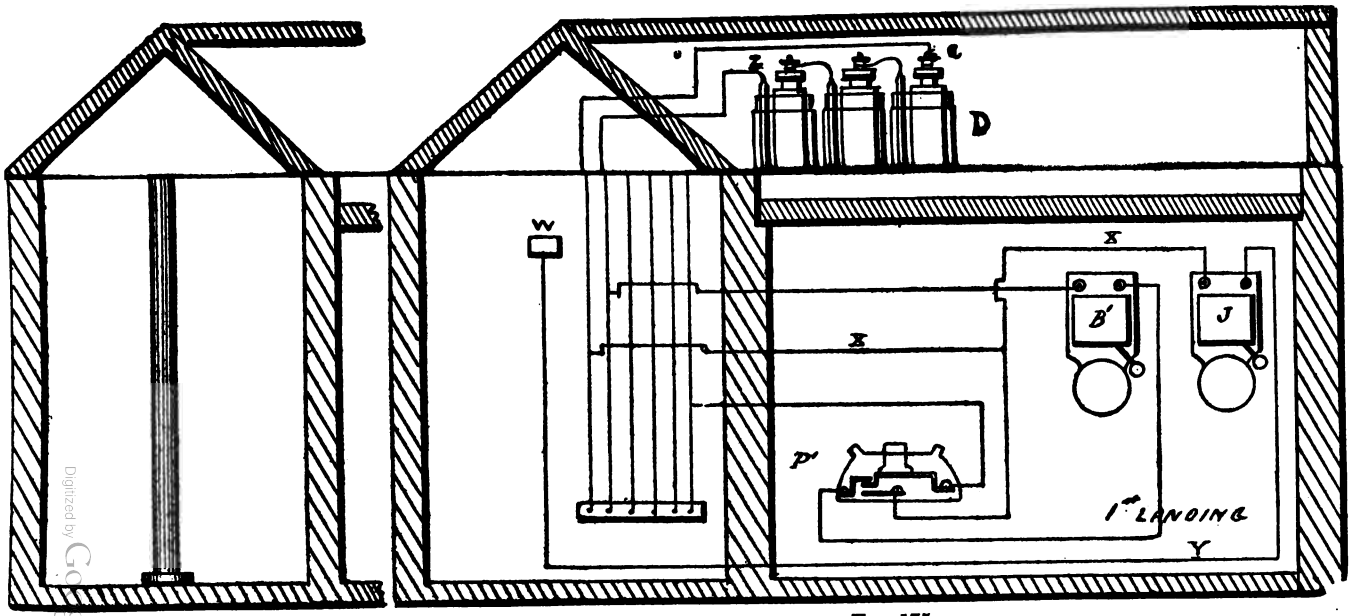

FIG. 177.

FIG. 175.

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replying. When the lift-cab is down at the bottom of the shaft, the spring *k* placed at the top of the cab makes contact with the brass plate W fixed in the shaft, and puts the bell J (which bell is fixed in the porter's lodge or any other place where the attendant is likely to be when not in the lift) in parallel with the bell B in the cab, so that if a signal is now sent from any of the landings, both bells will ring, the circuit being as follows :—Pole C of battery D, shaft wire *c*—here it has two paths to the wire *g*, one by wire X, bell J, wire Y, contact W, spring *k*, and wire R, and the other by spring *c*, wire *m*, bell B, there being a common return from both bells by wire *g*, rod *g*, shutter S, movement 3, wire *f*, spring Z, and zinc of the battery.

Fig. 176 is a side elevation showing the contact spring *s* fitted on to the cab *c* by means of the block *b*, and pressing against the shaft wire *w*. The springs should be set well in towards the wires at the bottom, and must not be too long; otherwise a disagreeable chattering noise will be made as the lift moves up and down. Brass springs are much to be preferred to any description of rollers, as these run round and round and have no tendency to keep the wires bright; thus the contact, after a time, becomes very indifferent. The wires scarcely wear at all, as most of the wear comes on the springs, which can easily be renewed at a trifling cost. The practice of hanging weights on the ends of the shaft wires, instead of fastening them off with the metal pegs, is not advocated, as it has a great tendency to cause the wires to break.

The battery should never be placed at the bottom of the lift shaft, as no matter what construction the lift, there is almost always some leakage, which keeps the place constantly wet. The best position, perhaps, is at the top of the lift shaft, where a beam can generally be found on which to stand it; but if this is not obtainable, it may be placed in some room the wall of

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which adjoins the shaft, and a hole knocked through for the wires.

Fig. 177 shows a lift-shaft and cab fitted with a bell and indicator, connection being made to the cab by means of a flexible cable. The connections of the pushes, bells, &c., for a lift worked on this system are the same as for the one just described, so the lift-shaft shown in Fig. 177 can be substituted for the one in Fig. 175. When wiring for a lift on this system, all the wires from the various landings must be run to a point (*a*) about half-way up the lift-shaft, and joined to one end of the cable. This cable must be composed of a number of small insulated wires, so as to be very flexible; and it is preferable to have each wire composed of a number of strands, as by this means the greatest flexibility is obtained. One end of the cable is suspended at the point *a*, and the other fixed to the top of the cab, being usually supported out a little way by means of a wooden arm. It will be seen, on comparison, that more insulated wire is used in this system, while there is the additional expense of a special cable, the lasting qualities of which are very doubtful.

Connections for Water-level Indicator.

Fig. 178 shows the connections for the water-level indicating contact shown in Fig. 115. The apparatus consists of a minimum and maximum contact, from each of which a wire is run to an indicator fixed where it is desired the signals shall be received. One wire goes to each drop of the indicator, which should preferably be of the mechanical replacement form. From the indicator the circuit runs to the alarm bell (which may be continuous ringing if desired) and thence to interrupting switch and battery to earth; one plate of each contact at the reservoir or tank also being connected to earth. If now

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the water in the reservoir rises so as to float the top float T the maximum or full contact is closed and a current is sent through the left-hand movement of indicator to alarm bell and earth. When the water falls so low that it ceases to float the

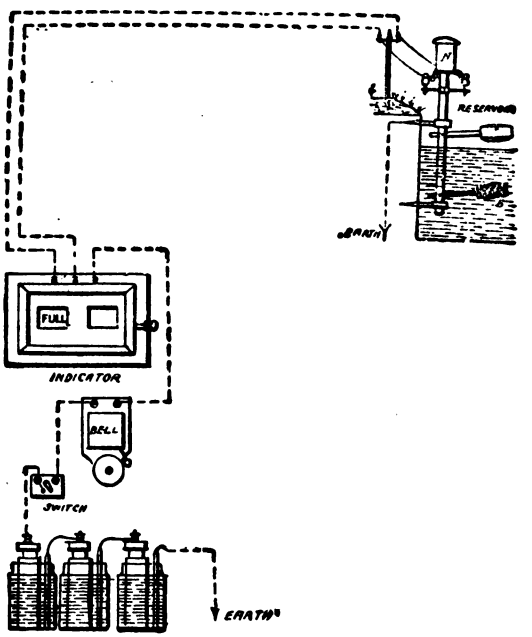

FIG. 178.—CONNECTIONS FOR MAXIMUM AND MINIMUM CONTACTS.

bottom float B, the minimum contact is closed and the right-hand movement of indicator falls. As soon as the bell is heard the circuit is opened by means of the switch below the bell.

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Connections for Recording Water-level Indicator.

Fig. 179 shows the connections for the water-level indicating apparatus shown in Figs. 116 and 117, p. 82. The apparatus consists of the recording apparatus as shown on the right-hand side, which is fixed at the reservoir or tank, and

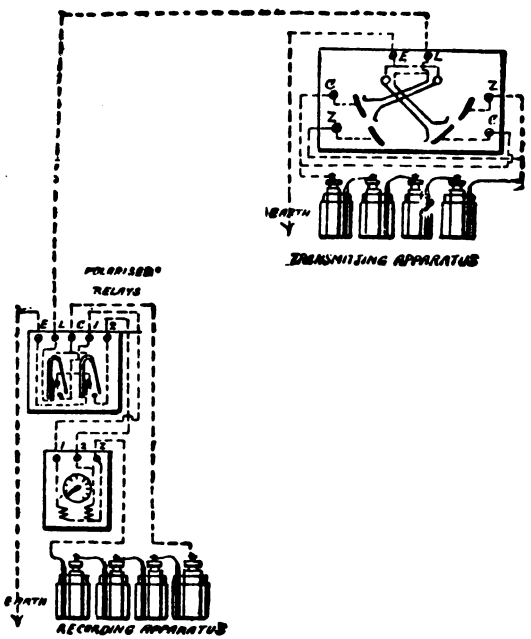

FIG. 179.—CONNECTIONS FOR RECORDING WATER-LEVEL INDICATOR.

operated by a float that by means of a cord and weight turns a pulley on the spindle S (see Fig. 116). As the float rises so the pulley is turned in one direction, while as it falls so it begins to retrace its movement. At the indicating end are

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fixed two polarised relays and a clockwork recording dial. Only one wire and an earth return is used, and a battery is provided at each end of the line. A description of the working of the apparatus will be found on p. 82.

Connections for Firemen's Call System.

The frontispiece shows a system of firemen's calls by means of which in event of a fire taking place an alarm bell is rung in each fireman's house by turning on a switch at the fire station. As will be seen from the illustration a wire is run from the fire station throughout the town, a connection being taken off at each fireman's house as the wire passes. The current passes through each bell and returns to battery at the fire station by "earth." The bells are thus all in parallel, and since they all ring at once it is necessary that a powerful battery be provided.

It is preferable also, to ensure greater certainty of action, to subdivide the town up into three or more circuits, working each circuit with its own battery and switch.

In the illustration the system is shown divided up into three circuits, each having its battery and switch. Circuit No. 1 runs to firemen Nos. 1, 2 and 3; circuit No. 2 to firemen Nos. 4, 5, 6; and circuit No. 3 to firemen 7, 8, 9. Each fireman has a bell B (3-inch vibrating) and switch S. The working of the system is as follows:—On an alarm being given the attendant at the fire station at once closes switches Nos. 1, 2 and 3, sending the current of batteries 1, 2 and 3 to their respective circuits. The bells now start ringing and each fireman as he is aroused or hears the alarm turns off the switch, thus cutting off the current from his bell. In houses that are far off the station it may sometimes be preferable to employ a continuous-ringing bell, as shown at No. 7, so that the bell once started

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continues to ring by current from the local battery. It is important that the firemen shut off their switches as soon as they hear the bell, as each bell shut off leaves more power available for ringing the others. The greatest strain on the batteries is of course at first closing the circuit, as the current is divided amongst the whole of the bells.

The wires to the different firemen are generally run overhead (No. 16 hard drawn copper) as shown in the illustration.

Explanation of Technical Terms.

We will conclude this chapter with an explanation of some of the technical terms used in electric-bell work.

Battery.—The combination of cells which furnish the current of electricity for working the bells, indicators, &c.

Cell.—Each outer jar of the battery, with its two elements and exciting fluids, constitutes a cell.

Circuit.—The wires, bells, indicators, batteries, &c., forming the path for the electricity.

Deflection.—The angle or number of degrees through which the needle of the detector moves during the passage of a current round the coils.

Earth return.—The use of the earth as part of the circuit.

Earth wire.—The wire from the bell, battery, &c., leading to the water or gas pipes.

Fault.—Any break or interruption of the circuit by which some of the operations are interfered with.

Line.—The wire joining one station with another.

Line battery.—The battery which is used to send the currents to line.

Local battery.—The battery placed near the bell or apparatus required to be worked, which continues the ringing of the bell

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after it has been once started by the current from the line battery.

Local circuit.—The circuit through which the current of the local battery flows.

Metallic circuit.—The use of another wire for return instead of earth.

To connect up. — To join the bells, indicators and other apparatus included in the circuit.

To disconnect.—To remove the ends of the wires from the terminals of the instrument, thus cutting it out of the circuit.

To make "earth."—To connect the wire to earth.

A short-circuit.—A fault caused by two wires coming together so as to form a shorter path for the current, diverting the whole or greater part of it from its proper course.

To short-circuit a cell.—To join the terminals with a piece of wire.

To short-circuit an instrument.—To join the terminals of the bell, &c., with a piece of wire.

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CHAPTER VIII.

THE DETECTOR, AND LOCALISING FAULTS.

BOTH for localising faults and in order to ascertain the condition of the batteries, a small galvanometer—sometimes called a "detector"—should be provided. Figs. 180 and 181 (which latter is full size) show the most usual form of this instrument, Fig. 180 being a front elevation and Fig. 181 a back elevation; the back part of the case having been removed at the hinges. As will be seen from the illustrations, it consists of a mahogany box, into the front of which a circular aperture has been cut. Inside this box is fastened the brass plate, one side of which is silvered and marked with a scale, the plate being so fixed that the scale is visible through the aperture. To the back of the brass plate are fixed the two brass bobbins, on which the wire has been previously wound, two bobbins being generally employed in preference to one, as this method makes the instrument more sensitive. The instrument has two needles—the smaller one working inside the brass bobbins, its lower or N. end being weighted for the purpose of bringing the needle to zero, the weight being merely such as will suffice to counteract the "dip" and keep the needle vertical. The other needle, which is lighter and longer, is placed in front of the dial, and immediately indicates the passage of a current through the coils of the detector by being deflected over the scale either to the right or left, according to the direction of the current. Both needles are carried by a common spindle, the front end

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of which is supported by a bar screwed on to front of the dial, and the back by a bridge seen between the bobbins in Fig. 181, the pivots in the more expensive instruments being jewelled.

The instrument is wound for "quantity and intensity" as it is usually called, the quantity or short coil consisting of a single layer of thick wire having a low resistance, generally some decimal of an ohm, and the intensity or long coil having

FIG. 180.—DETECTOR GALVANOMETER.

a number of layers of very fine wire with a resistance of 150 to 200 ohms. The ends of these coils are connected to the three brass terminals on the top of the case, so that terminals 1 and 2 will give the quantity coils, and terminals 1 and 3 the intensity coils. A brass ring is also fixed to the top of the case for convenience in carrying it about.

As, however, the scale of the detector is frequently hidden by the brass rim that holds the glass when standing on the ground, the scale is sometimes marked on the lower half of the

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dial; or a mirror is attached, which can be set at any angle, so that the scale can be easily seen when standing in almost any

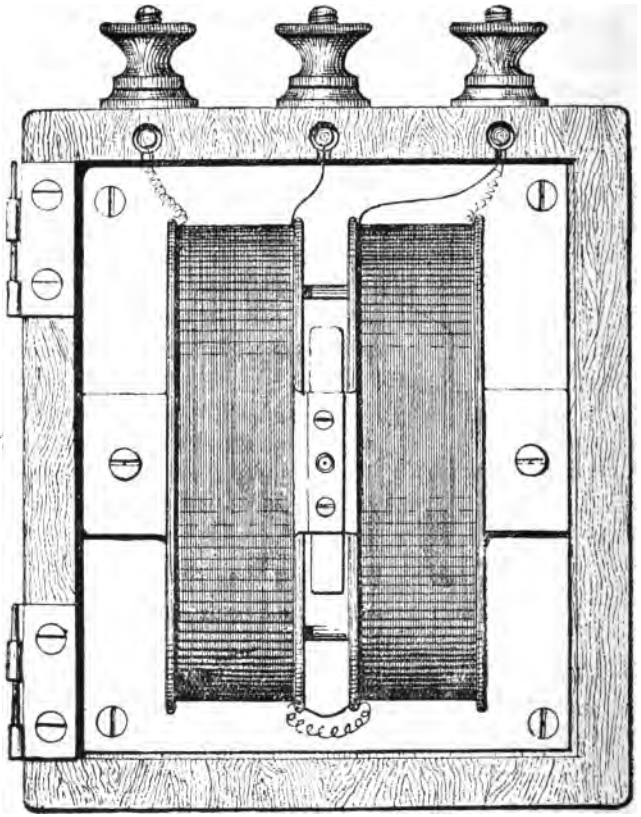

FIG. 181.—INSIDE OF DETECTOR.

position. Detectors can also be obtained with the intensity coil, provided with a shunt of one-ninth its resistance, so that

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when the shunt is put in circuit (which is done by means of a switch), one-tenth of the current only passes through the intensity coils, which greatly increases the utility of the instrument. The dial of the detector is graduated in degrees, and it may be as well to point out that the graduations on the scale are not proportional to the current flowing. They are fairly accurate up to 20°; but as the needle moves further and further from parallelism with the coils, the effect of the current gets less and less, until at right angles, or 90°, it is practically *nil*. As detectors vary considerably, no standard table of deflections for a certain current strength can be given; but each detector should be coupled up to a good cell of the different sizes, and the deflection noted for future use, the *quantity* coils being used for this test, as a very bad cell will give a good deflection on the fine-wire coils. A detector of the form shown in the drawing, and having the quantity coils wound outside the intensity, the resistance of the quantity being ·3 ohm, and the intensity 120 ohms, will give, roughly, on a newly set up Leclanché (porous pot form), No. 1, 26°; No. 2, 45°; No. 3, 60°; the deflection on the intensity coils being, of course, about the same for all sizes.

In addition to the detector, a low resistance voltmeter will be found very convenient. The condition of the cells can be better ascertained by its use, as it shows at once the E.M.F. of each cell. A form of this voltmeter in polished mahogany case is shown in Fig. 182. As will be seen from the figure, the instrument is "direct reading," the scale being graduated from one to four volts in fifths of a volt. It is also to be obtained with the scale graduated from one to three volts advancing by tenths of a volt, and this instrument is better suited to the purpose for which the bell-fitter will require it. When a newly set up Leclanché cell is coupled up to the voltmeter the needle will indicate an E.M.F. of 1·6 volts, but if the

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cell has been at work a long time and is nearly exhausted, its E.M.F. will be found to have considerably fallen, the deflection being now from ·8 to ·3 according to the state of exhaustion of the cell.

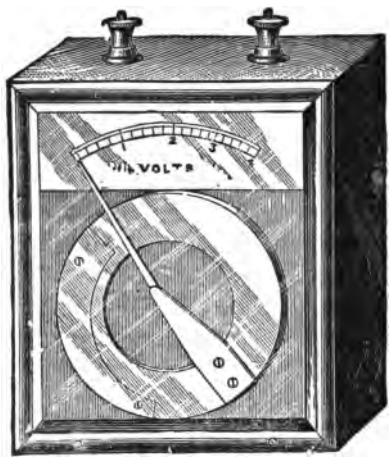

FIG. 182.—BATTERY VOLTMETER.

Faults in Electric-Bell Installations.

The length of time that the electric bells in a building will run without a "fault" may generally be taken as a pretty good proof as to the quality of the workmanship and apparatus. If good apparatus has been employed, and the wiring done in a thoroughly substantial manner, the bells should run for a year to eighteen months without the slightest attention, and the only expense then should be a few pence for recharging the battery. But if with a view to cheapness inferior apparatus and badly insulated wire are used, there will be a continual

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occurrence of faults throughout the entire building, and the bells will be nothing but an intolerable nuisance.

We will now turn our attention to some of the defects that may be looked for in the various apparatus.

Pushes will often give trouble from deterioration of the connection between the ends of the wires and the contact springs. If the wire used is not "tinned" the ends quickly oxidise, and unless they have been well inserted between the contact spring and the washer on the screw the connection rapidly deteriorates, finally introducing so much resistance that the bell will not ring through it. In ship-wiring the deterioration of these connections is much more rapid, and it is almost advisable in this case to secure the ends of the wires to the springs by soldering. In the best pushes the springs are of German silver or aluminium, the tips, at the point where they make contact with one another, being faced with platinum. Pushes thus constructed are very free from defects, but pieces of tin or other rubbish are frequently substituted for the platinum, or very often nothing is used at the point of contact but the surface of the spring itself. Trouble, therefore, often arises from insufficient contact between the springs themselves. The contacts may easily be tested to find out whether they are really platinum or not, by applying by means of a glass rod some nitric acid to the contact. If the metal bubbles up it is not platinum, but probably German silver, as platinum is not attacked by nitric acid. Sometimes a short circuit will occur between the two wires that run to the push, either from the insulation of the wires having been stripped too far back, or from the edge of the zinc tube, where it ends in the block at the back of the push, not having been turned over properly; the sharp edge of the tube penetrating the covering. When the hole in the back of the push is of insufficient size to permit of the two wires with their insulating covering being brought

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through, it is *always* better to enlarge the hole, in preference to the practice sometimes adopted of stripping the insulation of one of the wires right back, and bringing the two wires through the one bared of its insulation.

Bells, unless the workmanship is very bad, rarely give much trouble. They are liable, however, to get out of adjustment, and the ringing of the best bells can be spoiled for want of knowing how to adjust them properly. Bells in which the separate parts are not mounted on a wooden frame independently of the wooden base should never be used, as owing to the warping of the base they will never keep the same adjustment for any length of time. As in pushes, German silver is frequently substituted for platinum in the contacts, and if a bell rings badly and cleaning the contacts sets it right for a little while, some metal other than platinum may be suspected of being used. This should be tested as was advised in the case of the push-springs, care being taken to wipe off the acid should the contact be found to be platinum. Bells in which the bobbins are of metal instead of wood will frequently give trouble by the ends of the wires at the point where they leave the coil coming in contact with the cheeks of the bobbin, thus short-circuiting the bell. In the cheaper bells where an iron base is used either one or both of the terminals are insulated from the iron frame. These terminals owing to the vibration of the movement, sometimes work to one side and touch the frame, thus cutting the movement out of the circuit. Very often when a bell rings at one time and not at another, it will be found on inspecting the bell that the armature is sticking to the poles of the electro-magnet, thus holding the contact spring away from the post. This is due to the iron of the electro-magnet not being so soft as it should be, the magnet retaining sufficient magnetism, after the current has ceased, to hold the armature against its poles. As a prevention against this sticking of the armature the ends of the

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poles should be drilled and brass studs driven in, or a piece of thin gummed paper may be stuck on the inside of the armature.

Indicators will require a slight readjustment from time to time, though the pendulum or self-replacing ones are better in this respect than the other forms. Indicators with electrical replacements, owing to their delicate adjustment, require the most attention. It is useless to attempt to adjust the indicator till it is fixed in its place, for, however well adjusted it has been beforehand, it is sure to require a final adjustment after it is in its place. A good way to adjust the indicator is to take off a cell or two from the battery till the bell rings feebly, then adjust the different movements to work with this number of cells; the cells that were disconnected being joined up again after the adjustment is finished. This is preferable to adjusting the indicator with all the cells on, as when this is done, the movements being adjusted to work with the full current will often fail to act when the current strength is reduced, as is the case when the battery gets slightly exhausted.

After the wiring of a building has been completed, and the pushes, bells and battery fixed in their places, the wire from one of the poles of the battery should be disconnected, and the detector (using the intensity coils) inserted in the circuit in order to see if there is any leakage; for though any great leakage would probably manifest itself by causing the bell to ring, yet there might be a slight continual leakage, which, though it apparently does not affect the working of the apparatus, means a constant waste of battery power. Should a deflection be obtained when the detector is put into the circuit, the fault must be traced and removed, otherwise surprise may subsequently be expressed at the short life of the battery.

Faults in the wiring, as was before stated, will be few and far between if the wiring has been done in a substantial

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manner, but in the case of a badly wired building when the insulation once breaks down it rapidly passes from bad to worse. Putting in new lengths of wire is of little good, for it only breaks out somewhere else, and it is doubtful if anything short of rewiring the whole building will be found efficacious.

When renewing a length of wire that has given way in a building, where the insulation of the wires is in a doubtful state, the new piece should be run round the skirting, &c., in preference to drawing it into the tube by means of the old wire, as this will most probably only injure the insulation of the other wires. When a break or short circuit is suspected in one of the wires, the faulty wire can best be located at the indicator. For if a break occurs in the push of, let us say, No. 4 room, the indicator movement No. 4 will not act, or if a short circuit occurs between the two wires leading to No. 4 push, then No. 4 indicator vane will not stop up when replaced. The wire leading from this movement must then be traced back towards the push till the faulty place is found.

For outdoor work, such as when testing underground or overhead wires, a small portable wooden box containing three smallest size Leclanché cells and a detector will be found very convenient. When locating a break in an underground wire where an earth return is employed, the wire at one end of the line is disconnected from the instrument, while that at the other is left connected up. One end of the line thus makes earth, though the other is left free. Taking the box with cells and detector, and starting from the end of the line that is put to earth, we proceed along the line to the most accessible point and dig up the wire. We then put one of the poles of the battery to earth, which can be done by driving an iron rod into the moist ground, and connect the other to one terminal of the detector, using the fine wire coils. A short length of wire is

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next joined to the other terminal of the detector. With a knife the covering of the wire to be tested is removed, care being taken not to nick the wire or remove more of the insulation than is necessary to expose the copper, and the wire from the detector touched on the exposed place. If a movement of the needle of the detector is obtained the wire is intact between the place tested and the end of the line that is put to earth, but if no deflection is obtained the wire is broken in this part. Care must be taken to see that a good earth connection is made by the iron rod. If the circuit is complete so far, we must (having first well insulated the bared place on the wire with rubber tape) proceed to the next convenient place. Here we go through the same operation, and if the circuit is complete proceed to the next, and so on until no deflection of the needle of the detector is obtained, when the break will be between this place and the one last tried, at which the detector showed a deflection. From this place we then work backwards till the fault is found. It must be borne in mind, however, that this test is no good if the insulation of the line is faulty, and it makes "earth" anywhere, which should be previously ascertained.

If the fault was a leak to earth instead of a break, we must, before testing, remove the ends of the wires from the instruments at both ends of the line. We next proceed to the most accessible place in the wire (preferably where we know there is a joint), and, having arranged our detector as in the previous case, we cut the line wire and touch the end of the wire from the detector, first on one end of the line and then on the other; the part which gives a deflection being the faulty wire. We then try at different places in the faulty part till we succeed in localising the fault.

When a fitter is called to a fault in any building, he should touch nothing until he is pretty sure what is the cause of, or in

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what direction the fault lies. More especially should this be attended to in regard to the wires. He should not touch the wires until he is perfectly sure that the fault is in the wiring, for if the wires are cut here and there, as may be necessary when tracing a fault, it is seldom that the bare places, when bound up, will show the same insulation that they did before. He should first gain all information as to how and when the bells ceased to ring, or whatever the fault may be. If the bell rings and the indicator does not work, he should not necessarily conclude that the fault lies with the indicator, and forthwith fiercely attack the indicator with screw-driver and pliers, only to find, after he has taken the thing to pieces, that it was all right, and that the fault was really in the battery, which was nearly exhausted. The most frequent cause of the bells not ringing, is from the battery having run down. When a fitter is called to a fault, and is told that none of the bells will ring, he may generally suspect the battery of being exhausted. He should first inspect the battery, joining up the cells to the quantity coils of his detector, and comparing the deflection with that obtained from a good cell, and should it be found exhausted, it must be recharged, directions for which are given in Chapter VI., on Batteries. A break in the main wire close to the battery would cause a similar fault, and if the battery is found all right, this wire should be inspected. If the bell rings feebly while the battery is in good condition, a bad joint may be suspected in one of the wires. Faults occur in the pushes, and especially if the springs are not fitted with platinum contacts, and should the bell ring at one time, while it does not at another, dirty contacts will generally be found in the push; but if the push seems all right the fault may be in the bell. If the bell rings continuously, a contact between two wires may be suspected, or the push spring may have stuck. Pulls, and especially the one at the tradesmen's entrance, are

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very likely to cause the bell to ring continuously, as the spiral spring loses its set, and after a time does not move the disc (see Fig. 47, page 27) back clear of the springs, thus keeping the circuit closed.

When a fitter is out on "detective duty," he will rarely require his heavier tools, and the following articles (which will go easily into a small bag) he will find the most convenient to take with him :—

1 pair of taper nose-cutting pliers.
1 small screwdriver.
1 4-inch smooth flat file.
1 small rat-tail file.
1 bradawl.
1 small hammer.
3 spare zincs (one of each size).
A packet of salammoniac.
A small box of staples.
A sheet of emery cloth.
A few binding screws.
A small coil of No. 20 paraffin wire

As a parting word to electric bell fitters, and all who have anything to do with electric bells, I say, *Be thorough.* Do not leave a piece of work with the words, "Oh ! that will do," as nothing is so fatal to success in electrical work as apparatus erected in a manner that will only just *do.* If a fault occurs, put it right at once, and put it right thoroughly, not merely patching it up, thinking to put it right at some future time. If you are screwing up the adjustment screw of a bell, remember you are working at a bell ; and if you are adjusting an indicator, remember you are at work on an indicator, and not a 100 horse-power Galloway engine.

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CHAPTER IX.

PORTABLE SETS.

WHEN only temporary communication is desired between two places, what is known as a "portable set," will be found very convenient. These sets consist of a battery, bell and push, the battery generally being enclosed in a wooden case, to the outside of which is fixed the bell, connection being made between the bell and push by means of flexible wires. Portable sets are now to be found in innumerable shapes and designs, each manufacturer having his own arrangement. In order to aid the reader in the selection of a good portable set, we will just glance at a few of the more important points that should be looked to when making a purchase:—(1) If the set is to be carried from place to place, it is preferable that the battery should be either a "sealed" or a "dry" one. (2) The bell should give out a loud *clear* sound. (3) There should be suitable means of rapidly coiling and uncoiling the flexible wire from the push. (4) The set should have a neat appearance, and not be of an inconvenient size or shape; and (5) if the set is for the use of an invalid—such as to be used for summoning the nurse—the push or pressel should be so constructed as to work with the slightest pressure.

Portable sets that do not fulfil the first condition, i.e. contain a battery that is an ordinary or else a so-called sealed Leclanché, have the objection that they are confined to one position, and moreover, if accidentally upset, a by no means

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infrequent occurrence, the contents are precipitated on any articles that may happen to be standing near it. Trouble also arises in a set with a battery of this form from the solution, during transportation, splashing on to the terminals and destroying the connection. The "circular" bell is the one usually employed in portable sets, the hammer of the bell striking on a lug fixed on the inside of the gong. Sometimes, owing to bad construction or design, the gong gives out,

FIG. 183.—PORTABLE BELL SET.

instead of a clear musical sound, an unpleasant tapping one, and a set with a bell of this kind should be rejected, as it has not the penetrating effect of the proper bell. Bell sets that do not fulfil the third condition, have an untidy appearance, and the wire, owing to the want of something to wind it on when not in use, rapidly gets into tangles and kinks, which generally end in causing the wire to break at the kink. The wire employed is generally a twin wire, each wire, which is composed of a number of small strands, being insulated with

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silk. It is important that the set should have a good appearance, as, from the nature of its use, it is more exposed to view than the ordinary electric bell, which is generally fixed in an out-of-the-way place in the kitchen or corridor adjoining it.

Fig. 183 shows a form of portable set much used, it being intended for fixing temporarily and not for being transported from place to place. It consists of a polished walnut back-

FIG. 184.—BELL SET FOR LONG DISTANCES.

board, on the right-hand side of which is fixed a 2½ electric bell, and on the left, supported by a small stand, a No. 2 Leclanché cell. Connected to the terminals of the bell and cell is a 3-inch push, with 36 feet double wire attached. The bell set can be hung on the wall by passing a nail through the hole seen in the top of the board and the wires roughly strung along to where the push is desired.

Fig. 185 shows a bell set intended for communicating

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between places a greater distance apart than is allowed for by the usual bell sets. It has two No. 2 cells connected in series, above which is placed a 3-inch "shield" bell. It is provided with a 3-inch push and 66 feet of double wire, and the backboard is so arranged that it can either be stood on a shelf or hung on the wall.

A form of portable set suitable for carrying about from place to place is shown in Fig. 185. It consists of a polished walnut or mahogany case, the top of which opens with a lid

FIG. 185.—PORTABLE SET.

and is provided with a handsome brass handle for convenience in carrying about. On one side of the case is fitted a 3-inch best quality bell, with wood cover to match the case, while on the side adjoining are fixed two terminals, from which runs 12 yards of silk-covered flexible wire, having at the end a walnut-wood or rosewood pear push. The flexible cord when not in use is coiled round two brass arms fixed below the terminals. The battery, which is placed inside the case, is either a No. 2 sealed Leclanché or a dry cell.

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Fig. 186 shows a form of portable set having a three-button push board and a three-number mechanical indicator. The

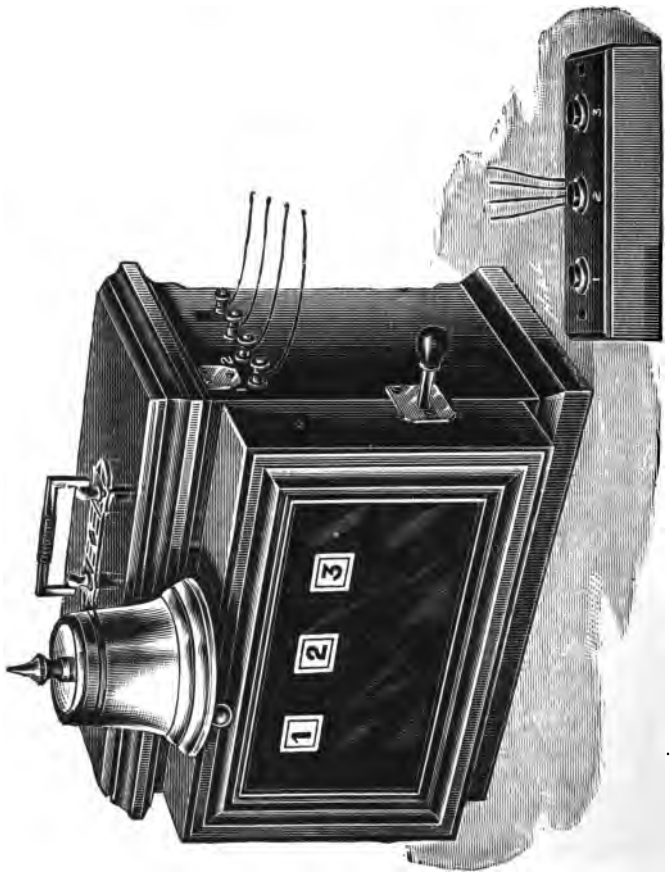

FIG. 186.—PORTABLE SET WITH INDICATOR.

bell is fixed above the indicator, and the battery, which is a three-cell one, is placed inside the polished wood case at the back of the indicator.

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